



# Australian Cotton Production Manual

2011



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**The Cotton Industry  
Development & Delivery Team**



Cotton Catchment Communities CRC

*Cotton*  
**D&D**  
*Team*

*Best Practice*





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# Foreword

By **KEN FLOWER**



Welcome to the expanded and improved second edition of *The Australian Cotton Production Manual*.

There have been upgrades made to most sections and there are four very important new sections added:

- **Reducing pesticide use – actively managing native vegetation**
- **Alternative irrigation systems**
- **Spray applications**
- **Whole farm water balance**

This publication serves as a key document to reference current cotton production practices, and as such, is a most important resource for all cotton producers, especially those entering the industry for the first time, or returning to it.

The Australian cotton industry has undergone major challenges over the past decade brought about by the reduction in availability of water due to drought, government restrictions and water buy backs. With a cotton area previous peak of 511,000 hectares planted in 2000 through to a low of 68,000 hectares in 2007, the whole industry from grower to research, development and extension (RD&E) has had to do more with less. Then the 2010/11 season saw the biggest cotton plant yet of some 600,000 hectares planted, with over 200,000 hectares being dryland cotton. This season has been arguably the most challenging weather we have experienced with several severe floods and heavy rainfalls in all production areas. Despite these challenges, the industry has shown its resilience by remaining best in class while adapting to the highly variable seasons and resource levels confronting it.

Cotton prices are high and look like remaining strong, and the storages have supplies for the coming seasons so the pressure is on now to sustain high production. We must remember that at these times of high opportunity there can still be risks associated with cotton production. These risks come in the form of: financial, pests, weeds, diseases and climatic. This manual is aimed at providing some of the knowledge to assess, plan and reduce these production risks with the benefit of experience, research and extension.

Also as we ramp up cotton production after some smaller seasons, we are increasing our capability and our human capacity and it is in these times of introducing new people and new assets where risks can be higher. So I would recommend the cotton industry's *myBMP* web based management system to help identify your practices

across 11 different modules. This system not only helps with a checklist across your operation but has valuable information and resources in each module. Visit [www.mybmp.com](http://www.mybmp.com) for more information.

The *myBMP* web manual helps growers make well informed decisions through providing the latest information, based on best management practices.

The Australian cotton industry is well known for its innovative approach to production, which has resulted in the industry being world leaders in terms of yields, quality, production costs per kilogram, and being among the most ecologically sustainable cotton produced anywhere in the world. These outstanding results have been achieved through:

- Quality and commitment of cotton researchers.
- A high and sustained investment in research.
- Industry wide input to research direction.
- A high quality group of professional cotton consultants.
- An open, sharing culture leading to fast adoption of best practices as they evolve.
- High level of cotton specific training of personnel.
- Supportive secondary industries and suppliers.
- Australia's open market maintaining our competitiveness.

This publication is one of a series of key products proudly brought to you by the cotton industry's 'Development and Delivery Team'.

This team is responsible for delivering a high quality Research Adoption Program to the cotton industry to encourage the early and maximum uptake of new research and innovation, leading to higher economic performance with a reduced ecological footprint.

The quality of the content in this publication is testament to the excellent body of research and researchers we have in the industry.

You will see from the authors and credits the impressive range of researchers and organisations which combine to produce this document. In addition to industry resources, Greenmount Press and the sponsors have played a vital role in helping achieve the quality and timeliness of this publication at the lowest possible cost to the people on the ground. I look forward to this collaboration continuing for future publications.

Thanks again to the Researchers, the Development and Delivery Team, to Tracey Leven for her thorough review, and Helen Dugdale who has led the whole publication. It is now available for an anticipated strong and re-building cotton industry over the coming seasons.

**Ken Flower**

**General Manager Research Implementation and *myBMP***





# Development & Delivery Team...

*This publication brought to you by the Cotton Industry Development and Delivery Team.*



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*The Cotton Industry Development and Delivery Team recognises and appreciates all contributors to the second Australian Cotton Production Manual*





# Cotton industry organisations

## Who, What, Where

### Cotton Australia

Cotton Australia was established almost 40 years ago to support Australia's cotton growers and represent their interests. In 2008, the organisation merged with a key research partner, the Australian Cotton Growers Research Association (ACGRA). The timely consolidation of these two leadership bodies followed a long period of discussion and consultation around the best structure for the cotton industry moving into the next decade. With over 90% of members shared, a merger has reduced duplication and provided human resource and cost efficiencies. It has also provided a sole voice for grower representation and captured the synergies between research and policy.

Cotton Australia determines and drives the industry's strategic direction, retaining its strong focus on R&D, promoting the value of the industry, reporting on its environmental credibility, and implementing policy objectives in consultation with its stakeholders.

One of Cotton Australia's key roles is that of advocacy, positioning the industry within the political framework to reduce regulatory burdens on cotton growers and advancing their interests at all levels. Cotton Australia opens the doors to senior politicians and policy makers at Federal and State levels. The organisation lobbies hard on a huge range of political issues that confront growers and defends the industry from the impacts of new legislation.

For example, Cotton Australia has been at the heart of the water debate for over a decade, fighting hard on all fronts for growers' rights, and coordinating industry responses alongside other groups such as the National Farmers Federation.

Cotton Australia works to ensure an environment conducive to efficient and sustainable cotton production. In the past three years, Cotton Australia listened to growers and made major changes to the myBMP program so that it works better, is simpler and brings all the industry's resources together. Cotton Australia leads this program that allows us to establish our sustainability credentials with government and the community.

Cotton Australia pushes for better funding for rural R&D and provides grower-driven feedback to the CRDC on where they should invest their research dollars.

Cotton Australia helps to safeguard the industry by remaining vigilant and prepared for risks like biosecurity threats and exotic pest incursions.

Cotton Australia's Regional Managers attend to grower

issues at a local level, providing a local listening post so that policy is directed to the areas that matter most. Cotton Australia has two regional offices in Narrabri (NSW) and Toowoomba (QLD) from where staff provide direct and daily support to growers.

Cotton Australia has recently increased its resources to promote the cotton industry to the Australian community, and works hard to position the industry in a positive way to counter negative perceptions.

Cotton Australia is a more streamlined and cost-effective organisation following its merger with the ACGRA in 2008 – growers get more for their money now than ever before and can be confident of an efficient and truly grower-representative structure. Cotton Australia is funded by a voluntary levy of \$2.25 per bale of cotton, and cannot operate without this support.

Cotton Australia will continue to work with and on behalf of growers to Advance Australian Cotton.

[www.cottonaustralia.com.au/](http://www.cottonaustralia.com.au/)

### Cotton Catchment Communities CRC

The Cotton Catchment Communities CRC (Cotton CRC) exists to provide high quality collaborative research and education, and to facilitate the adoption of activities that benefit the Australian cotton industry and regional communities in Australia. Partners participating in the Cotton CRC are:

- Cotton Australia Ltd.
- Cotton Research and Development Corporation.
- Cotton Seed Distributors Ltd.
- CSIRO.
- Industry & Investment NSW.
- Queensland Department of Employment, Economic Development & Investment.
- Department of Agriculture and Food WA.
- The University of New England.
- The University of New South Wales.
- The University of Sydney.
- University of Technology – Sydney.

The Cotton Catchment Communities CRC Limited is a registered company formed through the collaboration of private sector, federal and state government agencies, industry associations and Universities. The Cotton CRC has entered into a formal agreement with the Commonwealth Government that outlines the agreed milestones to be achieved over a seven year term from 2005 to 2012. The Commonwealth provides a certain level of funding each year to assist in the undertaking of the agreed activities. The Commonwealth Agreement also identifies the contributions (including cash and in-kind) that will be made by the Cotton CRC participants. The Cotton CRC's partners have committed significant funding, resources and research expertise to the Cotton CRC's research, education and extension agenda.

Cotton CRC aims to facilitate the delivery of a cotton industry that:





- Secures international competitiveness using research to increase yield and fibre quality;
- Adopts world's best practice in production, environmental and catchment management; and,
- Generates improved social and economic conditions in cotton communities.

### **Our mission**

Cotton Catchment Communities CRC aims to provide high quality collaborative research, education and adoption activities which benefit the Australian cotton industry, regional communities and the nation.

### **Our outcomes**

- Internationally competitive cotton farming systems.
- Best Practice cotton enterprises delivering sustainable ecosystems and reduce impacts on catchments.
- Mutually beneficial interactions between industry and regional communities.
- High quality consumer preferred cotton.
- Increased adoption of new knowledge and enhanced decision-making capability of people working in or with the cotton industry, its catchments and communities.

[www.cottoncrc.org.au](http://www.cottoncrc.org.au)

## **Cotton Research and Development Corporation (CRDC) science underpins the success of the Australian cotton industry**

The role of the Cotton Research and Development Corporation (CRDC) is to enhance the performance of the Australian cotton industry and community through investing growers' R&D levies and Government funding in research, development and its application. In doing so, the CRDC's quest is for the Australian cotton industry to achieve sustainable competitive advantage.

The Rural RDC and supporting levy system was introduced nationally in 1990 and has enabled industries such as cotton to improve their performance and maintain market position in a highly competitive world. The international competitive advantage that Australian cotton producers enjoy in 2011 is in a large part based on the 20 years of research and development investments in which industry and government has partnered. Coupled with the application of science in the field is a resilient, responsible and committed industry that has a long-term vision for its future. It is this commitment to science that sees the Australian cotton industry among the most productive, efficient and sustainable agricultural production systems in the world.

All cotton farmers pay an R&D levy of \$2.25 for each 227 kilogram bale of cotton. This is collected by cotton ginners on behalf of the Australian Government. The Australian Government then provides CRDC with the resultant growers' levies and matching R&D funding.

CRDC plays a key leadership role in setting the strategic direction and managing research and development investments in the Australian cotton industry. In doing so it is accountable to the industry, through Cotton Australia and the Australian Government, through the Minister for Agriculture, Fisheries and Forestry. For their part, growers influence the direction of industry R&D through their membership of Cotton Australia. This is a relationship that is formally recognised by Government.

CRDC invests in a portfolio of research, development and extension projects undertaken by the Cotton CRC and many other research and development organisations, consultancies and people.

All investments are selected on the basis of improved environmental, social and economic benefits to the industry and the nation.

CRDC coordinates the development of technical and non-technical documents, guides and other information tools and coordinates workshops, seminars and field days for a range of purposes including research review and progression, information sharing and technology transfer to industry.

CRDC produces a range of publications about corporate activities and operations and disseminates research outcomes. It acts as a formal and informal information source for stakeholders and client groups (facilitated by its location in a major cotton growing centre), through general industry media activities and the Corporation's website, [www.crdc.com.au](http://www.crdc.com.au).

CRDC's research partners are also actively involved in the dissemination of research results, working through a range of mechanisms including their own organisations and also through CRDC-supported National Cotton Development and Delivery Team (D&D Team).

### **Key research partners and co-investors**

**Cotton Catchment Communities CRC**

**Cotton growers**

**Rural Research and Development Corporations**

**CSIRO**

**Universities**

**Cooperative Research Centres (CRCs)**

**Industry and Investment NSW**

**Queensland Department of Employment, Economic, Development and Innovation**

**State Government Departments**

**Crop Consultants Australia**

**Cotton Australia**

**Agribusinesses**

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**[www.crdc.com.au](http://www.crdc.com.au)**



# Introduction

By **MIKE BANGE**, CSIRO



The cotton fibre is unique in generating a host of products that sustain and make life more comfortable and aesthetically appealing. Australian cotton is viewed worldwide as an excellent fibre. It is generally purchased with the intention of producing high quality combed, ring-spun

yarns for use in the woven and knitted apparel sector in the Asia-Pacific region. China is also becoming an increasingly significant market. Australian cotton is often purchased for a premium as it meets many of the spinner's requirements on the basis of quality and consistency. It has the specific fibre qualities required to spin high-quality yarn and produce desirable high value textile products.

Cotton fabrics dating back to 3000BC are proof of the long history of the cultivation of cotton and its importance as one of the most popular natural textiles around the world. Two cotton species are grown in Australia, *Gossypium barbadense* and *Gossypium hirsutum*. The cottons are called New World cottons and originated in Central America. *Gossypium hirsutum* (called Upland) represents more than 90% of Australia's and the world's cotton production as it is most productive and has suitable fibre properties for modern textile production. *G. barbadense* cottons have a number of names – Pima, Egyptian, Peruvian, Sea Island, and so on.

These cottons have very good fibre properties demanding a significant price premium from spinners for manufacture of fine garments. It has lower yield and narrower climate requirements – requiring specific management. In Australia, Pima production has been limited to western NSW locations such as Bourke, Hillston and Tandou.

The First Fleet brought cotton with them to Australia in 1788, however the first plantings in the Sydney area



**Cotton flower.**

were disappointing, due to the unfavourable climate. Early production was then confined almost entirely to Queensland, with the first commercial crops grown at Moreton Bay Queensland in 1840.

Australia's 'modern' cotton industry as we have come to know it today, was started in the early 1960s, largely in the Namoi Valley of NSW. From these modest beginnings, the industry has expanded the growing region as far south as Hay and Griffith in NSW to Emerald in Queensland, with small plantings further north in the Burdekin Region and the Ord River area in Western Australia.

The Australian cotton industry is one of the nation's biggest rural export earners and is vital for the prosperity of many regional communities.

Growers considering cotton farming for the first time should first have the capital resources required to grow the crop and be committed to a high level of managerial expertise and best management practice.

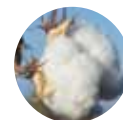
This publication serves to give growers, new and old alike, key information to help successfully and sustainably grow high yielding and high quality cotton, and provide advice on where to obtain more detailed information and tools when necessary. There is an abundance of reference material and resources available to current and prospective growers, which can be found, downloaded or ordered from the list below.

In addition to these resources, the industry has also invested heavily in the development of industry best

## BE AWARE OF

- Suitable climatic summer cropping conditions.
- Inputs in terms of costs – per hectare (\$... dryland/\$... irrigated) and water availability (if irrigated), machinery start up costs.
- Cash flow budget is essential.
- Services of a reliable and experienced consultant/agronomist.
- Availability of suitable machinery, either purchased, contracted or shared.





management practices. 'myBMP' is a key tool growers can use to help them achieve best practice in growing cotton sustainably and responsibly. It can also be used to help direct growers to the latest information from the industry and the cotton research community on specific issues relating to cotton farming as a whole.

Go to the *myBMP* website – [www.mybmp.com.au](http://www.mybmp.com.au) for more details and to register.

To receive the latest industry information and publications, add your details to the Cotton Industry Mailing list by contacting Dave Larsen at the Cotton CRC – [david.larsen@industry.nsw.gov.au](mailto:david.larsen@industry.nsw.gov.au) or 02 6799 1534.

## IMPORTANT INDUSTRY CONTACTS

### Cotton Australia (CA)

Ph: 02 9669 5222 – [www.cottonaustralia.org.au](http://www.cottonaustralia.org.au)

### Cotton Research & Development Corp (CRDC)

Ph: 02 6792 4088 – [www.crdc.com.au](http://www.crdc.com.au)

### Cotton Catchment Communities CRC (CCCCRC)

Ph: 02 6792 2446 – [www.cottoncrc.org.au](http://www.cottoncrc.org.au)

### Crop Consultants Australia (CCA)

Ph: 0429 925 459 – [www.cropconsultants.com.au](http://www.cropconsultants.com.au)

### CSIRO (ACRI Narrabri)

Ph: 02 6799 1500 – [www.csiro.au](http://www.csiro.au)

### NSW Department of Industry & Investment (I&I)

ACRI Narrabri

Ph: 02 6799 1500 – [www.dpi.nsw.gov.au](http://www.dpi.nsw.gov.au)

### Qld. Department of Employment, Economic Development and Innovation (DEEDI)

Ph: 07 3001 6359 – [www.deedi.gov.au](http://www.deedi.gov.au)

### Cotton Seed Distributors (CSD)

Ph: 02 6795 0000 – [www.csd.net.au](http://www.csd.net.au)



### Fertiliser Rigs

- ✓ Up to 3 tonne capacity with exceptional stability and ease of lifting
- ✓ 770mm of underframe clearance for brilliant trash flow
- ✓ Proven stainless steel metering units for corrosion resistance
- ✓ Can apply gas at same time as fertilisers



### Stubble Warrior

- ✓ Plant wheat back into cotton hills
- ✓ Double disc
- ✓ Single disc
- ✓ Gassing and/or fertilising



### Excel Penetrator

- ✓ 4, 6, 8 row
- ✓ Side busting/centre busting capabilities
- ✓ Adaptable for gassing or dry fertiliser
- ✓ 5/8" inline shear bolts
- ✓ Unrivalled trash clearance



### Cultipacker

- ✓ Machine can be pulled one way for aggressive soil breakdown and the other way for refining the soil before planting



## EXCEL CULTIVATOR

# EXCEL Agriculture

A DIVISION OF GREAT WESTERN CORPORATION PTY LTD (ABN 91 064 434 475)

*Australian made and owned*

74–92 Buckland Street, Toowoomba Qld 4350

**PH: 07 4636 9100**

**FAX: 07 4636 9140 — [www.excelagr.com.au](http://www.excelagr.com.au)**

# myBMP

By JIM WARK



*myBMP* is a new web-based management tool launched in 2010 that provides Australian cotton growers access to the industry's best practice standards, supported by the latest scientific knowledge, resources and technical support. It represents a complete rejuvenation and extension of the original BMP

system providing growers with tools to:

- Help improve on farm production performance.
- Better manage business risk.
- Maximise potential market advantages.
- Demonstrate responsible and sustainable natural resource management to the community.

*myBMP* is the result of industry wide consultation with growers, researchers and industry bodies, taking into consideration the requirements of the cotton industry now and into the future. The initiative is strongly supported by the Cotton Research Development Corporation, Cotton Australia and the Cotton Catchment Communities CRC.

## GETTING STARTED IS EASY

*myBMP* can be accessed via [www.myBMP.com.au](http://www.myBMP.com.au) – once on the home page, selecting the “Register Here” text will take you through the registration process (Tip – the “Demonstrations” text will allow you to access a video tutorial, showing you how to complete the process – once registered you can watch virtual tours of all of the *myBMP* features from the Grower Home Page).

**Support** – If at any time you have questions about *myBMP*, you can either email the *myBMP* Service Manager via [admin@myBMP.com.au](mailto:admin@myBMP.com.au) or call **1800 COTTON** for one-on-one support

## WHY USE *myBMP*?

- **Focus is on continual improvement, flexible system, resources, simplicity and no doubling up.**
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# Dryland cotton

By **MIKE BANGE**, CSIRO



This chapter presents information to assist in establishing differences in yield potential, reliability and risks for dryland cotton between row configurations and regions. Extensive field research has been utilised including the use of the OZCOT crop simulation model coupled with historical climate records.

Dryland cotton growers need not take uncalculated risks. History can often serve as our best guide to the potential risks and benefits of different cropping strategies. The use of crop simulation models is a powerful, and often the only way, to address such issues without suffering the consequent pain and real life experience when misfortune strikes. CSIRO at Narrabri has used long-term climatic records (1957 onwards from the Bureau of Meteorology) and the OZCOT crop simulation model originally developed by Brian Hearn CSIRO Plant Industry, to study the prospects for dryland cotton production in different regions.

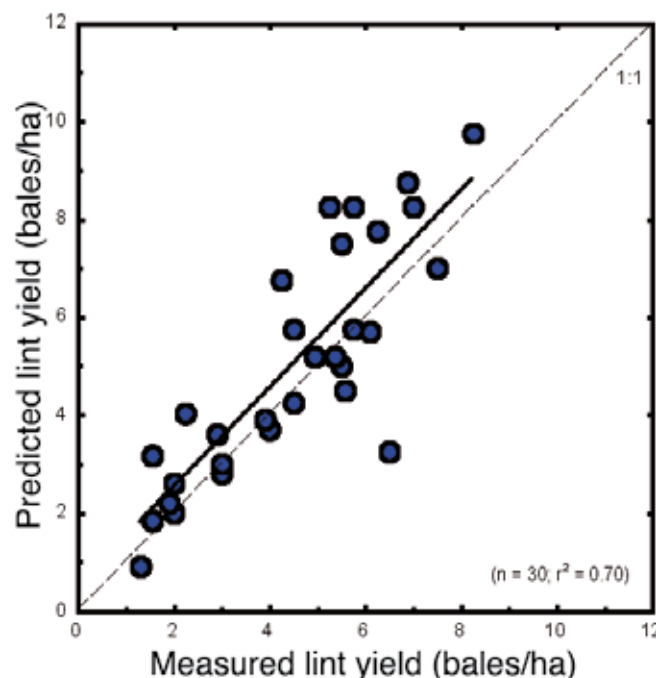
The OZCOT crop simulation model uses historical weather data, basic soil parameters, and defined management options to give estimates of potential crop yields. The model has been comprehensively tested across both commercial dryland (including skip rows) and irrigated crops throughout the industry (Figure 1). The intention behind skip row configurations is to

## BE AWARE OF

- Soils with a greater plant available soil water holding capacity reduce risks associated with dryland production. As with all dryland crop production, full profiles also significantly reduce year to year variation in yields.
- The optimal sowing window in most regions is 15th Oct to 15th Nov.
- Skip row configurations reduce the potential 'downside risk' in years with low rainfall.
- Double skip is more suitable for soils with lower plant available water holding capacity.
- Average fibre length is improved with skip configurations compared with solid.
- Seasonal climate outlooks such as the El Niño – Southern Oscillation (ENSO) phenomenon should also be considered as it can lead to differences in potential yield and associated risk.
- Average rainfall and variability between October and April in your region.

**FIGURE 1.**

Predicted lint yield (bales/ha) versus observed lint yield for commercial dryland cotton crops with various row configurations grown in southern Queensland and northern New South Wales. Also shown is the 1:1 line. In this comparison, the closer points are clustered around the 1:1 line drawn on the graph, the better the predictions made by OZCOT. The 1:1 line is the position on the graph where the simulated yield equals the predicted yield. (published Bange et al., 2005; AJAE (45 pp. 65–77))



provide slowly available soil water to the planted rows to allow continued growth during dry periods. In practice, the benefits lie primarily in: (a) a reduced risk of negative effects of water stress on fibre quality, (b) reduced

**TABLE 1.**

Average rainfall for cotton producing regions between the months of October and April as well as between December and March (Source: Australian Rainman).

| Region      | Rainfall October to April (mm) | Rainfall December to March (mm) |
|-------------|--------------------------------|---------------------------------|
| Hillston    | 212                            | 121                             |
| Narromine   | 303                            | 183                             |
| Warren      | 310                            | 194                             |
| Gunnedah    | 407                            | 253                             |
| Coonamble   | 326                            | 205                             |
| Wee Waa     | 391                            | 251                             |
| Bellata     | 409                            | 263                             |
| Moree       | 396                            | 258                             |
| Croppa Ck   | 404                            | 265                             |
| Goondiwindi | 426                            | 281                             |
| Dalby       | 488                            | 319                             |
| Biloela     | 534                            | 373                             |
| Emerald     | 489                            | 356                             |



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yield variability, and (c) better economic returns due to production costs being reduced more than the yield relative to solid planted cotton.

## Rainfall

Obviously the main consideration for dryland production and a source of variability across regions is rainfall. Regions differ greatly in the average total amount of rainfall as well as the variability between and within seasons. Generally, the risk of less rainfall between the months of October and April is greater in the southern cotton growing areas (Table 1). The traditional dryland cotton growing areas have higher average rainfall during these months, coupled with higher rainfall during the December through March period when flowering and boll filling occur.

## Predicting dryland cotton yield potential

The information presented in this chapter uses the OZCOT crop simulation model developed by CSIRO Plant Industry. Some assumptions used in this study were:

- Crops grown on cracking clay soils storing 200mm or 250mm of available soil moisture in 1.5 m profile. A full profile at sowing.
- Siokra (Bollgard II®) variety.
- Crops sown on 30th October.
- Row spacing set at 1 m.
- Established population of 7 plants per metre of row.
- Nitrogen is non-limiting.
- Climate data 1957–2010.

The model simulates potential yield. It does not account for the affects of insect pests, diseases, weeds, management failures, and soil nutrient limitations other than N. The model also does not simulate the effects of climate and

**TABLE 2.**

Probability of failing to sow based on the sowing rule (defined above) for different periods starting 15th September.

| Region       | Probability of failing to sow (%) |                      |                      |                              |
|--------------|-----------------------------------|----------------------|----------------------|------------------------------|
|              | 15th Sep to 15th Oct              | 15th Oct to 15th Nov | 15th Nov to 15th Dec | Overall 15th Sep to 15th Dec |
| Gunnedah     | 43                                | 15                   | 14                   | 24                           |
| Wee Waa      | 49                                | 18                   | 25                   | 31                           |
| Bellata      | 55                                | 21                   | 13                   | 30                           |
| Moree        | 42                                | 16                   | 18                   | 25                           |
| Croppa Creek | 36                                | 18                   | 17                   | 30                           |
| Goondiwindi  | 39                                | 17                   | 24                   | 27                           |
| Dalby        | 52                                | 10                   | 10                   | 25                           |
| Biloela      | 52                                | 18                   | 10                   | 27                           |
| Emerald      | 50                                | 33                   | 17                   | 33                           |



management on fibre quality, which is another important consideration when growing dryland cotton.

## Sowing opportunities

The risk of failing to obtain a sowing opportunity was assessed for three, 30 day periods starting 15th September. A sowing opportunity was defined in terms of adequate soil moisture and temperature and there was no account for Bollgard II® sowing window restrictions.

A sowing opportunity was considered to occur when there was:

- 25mm (1") of water in the top 100mm (4") soil; and,
- 18°C mean temperature for 3 consecutive days.

The Darling Downs, Moree and Gunnedah were found to have a slightly lower risk of failing to sow for the 90 day period starting 15th September for dryland cotton production than for most other areas especially for the period 15th October to 15th December (Table 2). Experience in these regions is commensurate with these findings.

**TABLE 3.**

OZCOT predictions, *solid* row configuration – effects of two plant available soil water holding capacities on potential yield (bales/ha) and variability of yields, expressed in terms of probability of exceedence.

| Region      | 200mm Plant Available Soil Water |     |     | 250mm Plant Available Soil Water |     |     |
|-------------|----------------------------------|-----|-----|----------------------------------|-----|-----|
|             | Mean                             | 80% | 20% | Mean                             | 80% | 20% |
| Gunnedah    | 3.1                              | 1.9 | 4.6 | 3.9                              | 2.5 | 5.5 |
| Wee Waa     | 3.3                              | 2.0 | 4.8 | 4.0                              | 2.7 | 5.7 |
| Bellata     | 3.4                              | 2.2 | 4.7 | 4.1                              | 2.8 | 5.4 |
| Moree       | 3.1                              | 2.0 | 4.4 | 3.8                              | 2.7 | 5.3 |
| Croppa Ck   | 3.4                              | 2.1 | 4.9 | 4.1                              | 2.8 | 5.5 |
| Goondiwindi | 3.3                              | 1.9 | 4.7 | 3.9                              | 2.5 | 5.4 |
| Dalby       | 3.4                              | 2.0 | 4.7 | 4.1                              | 2.8 | 5.2 |
| Biloela     | 3.4                              | 2.5 | 4.5 | 4.3                              | 3.2 | 5.5 |
| Emerald     | 3.5                              | 2.4 | 4.4 | 4.2                              | 3.1 | 5.2 |





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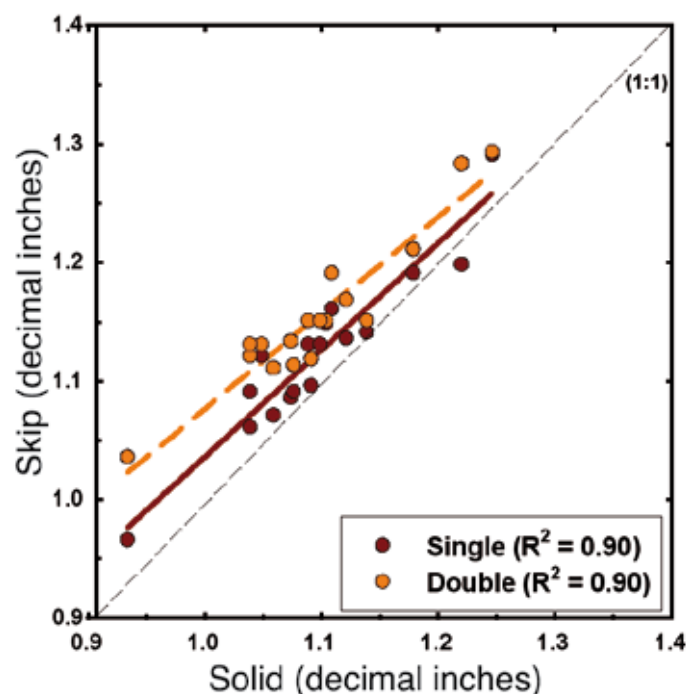
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**FIGURE 2.**

Fibre length of skip row configurations compared with solid row configuration in dryland cotton systems. As points approach the 1:1 line, fibre length of the skip configurations equals that of the solid configuration (M. Bange, CSIRO). Note that this data is not simulated data.

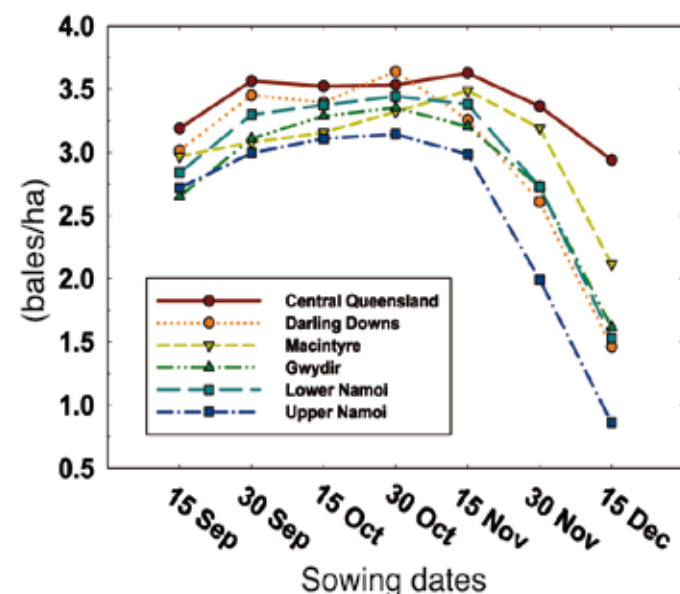


## Dryland regional yield potential and row configuration

A number of field studies have been conducted to compare the relative yield of skip row configurations compared with solid 1 m plant configurations. They generally show that when yields of solid configurations are high, skip row configurations have a penalty; however when yields of solid configurations are low

**FIGURE 3.**

Change in expected mean crop yield with sowing date. Yields have been predicted using a single skip configuration and plant available water holding capacity of 200mm.



the difference in yield between skip rows and solid configurations are small. It should also be noted that there are also significant fibre quality advantages attained from skip row configurations. Figure 2 shows data from experiments to highlight this point.

In tables 3, 4, and 5 the average potential yield from three different row configurations (solid, single and double) is presented on a regional basis along with the associated 'Probability of exceedence' values. Probability of exceedence is used to indicate yield variability that exists with different seasonal climatic conditions experienced in each region. For example an 80% probability of exceedence means that there is an 80% chance of at least achieving the yield presented for that region.

Generally across all regions, yields were improved with single skip and overall yield variability was reduced. Yield was also lower and more variable for solid. Mean yield across most regions was slightly less for double skip compared with single skip, but there were more chances (i.e. higher 80% and lower 20% probability of exceedence) of attaining better yields with double skip in soil with a lower plant available water holding content (200mm vs. 250mm).

## Time of sowing

The length of sowing windows in dryland crops is longer than for irrigated crops as the length of growing season is less for dryland cotton. While there is a trend for yields to slightly increase until late October, avoiding high temperatures during early flowering, the optimum sowing time for most regions based on mean yields was from 15th October to 15th November. In all regions mean yields of crops grown in single skip configuration were less when crops were sown early before 30th September (Figure 3). The latest sowing date where there was no substantial penalty to average yield was 15th November

**TABLE 4.**

OZCOT predictions, single skip row configuration – effects of two plant available soil water holding capacities on potential yield (bales/ha) and variability of yields, expressed in terms of probability of exceedence.

| Region      | 200mm Plant Available Soil Water |     |     | 250mm Plant Available Soil Water |     |     |
|-------------|----------------------------------|-----|-----|----------------------------------|-----|-----|
|             | Mean                             | 80% | 20% | Mean                             | 80% | 20% |
| Gunnedah    | 3.3                              | 2.4 | 4.3 | 3.8                              | 3.0 | 4.8 |
| Wee Waa     | 3.4                              | 2.4 | 4.4 | 4.2                              | 3.2 | 5.0 |
| Bellata     | 3.6                              | 2.6 | 4.8 | 4.3                              | 3.4 | 5.0 |
| Moree       | 3.3                              | 2.2 | 4.4 | 4.0                              | 3.0 | 5.0 |
| Croppa Ck   | 3.6                              | 2.4 | 4.8 | 4.4                              | 3.2 | 5.5 |
| Goondiwindi | 3.4                              | 2.4 | 4.3 | 4.1                              | 3.4 | 4.9 |
| Dalby       | 3.6                              | 2.5 | 4.4 | 3.9                              | 3.1 | 4.6 |
| Biloela     | 3.5                              | 2.7 | 4.0 | 3.9                              | 3.0 | 4.6 |
| Emerald     | 3.5                              | 2.5 | 4.5 | 4.3                              | 3.1 | 5.2 |





for all regions with the exception of the Darling Downs, where yield reduced after 30th October. Later sowings within this window can give the crop more time to capture rainfall when the crop needs it most. Sowing times outside this window not only reduce mean yield but also increase potential yield variability (Table 6). Consideration must also be given to the timing of crop maturity, which may be influenced by sowing, as rainfall at harvest can affect lint quality considerably.

## Seasonal climate forecasts to assess risk

Seasonal climate forecasts, based on the El Niño – Southern Oscillation (ENSO) phenomenon, may offer opportunities to adjust crop management in the light of probable future weather trends.

A useful way of interpreting seasonal forecasts is by identifying similar years in the climate history for the site of interest. Seasonal patterns in ‘similar’ seasons can be used as a guide for the potential risks and outcomes for the seasonal forecast. Outcomes of management decisions can then be assessed in terms of rainfall probability, average yields and the risks associated in achieving these yields for the coming season. While there are a number of ways of grouping similar years, one of the most successful approaches for partitioning

**TABLE 5.**

OZCOT predictions, *double skip* row configuration – effects of two plant available soil water holding capacities on potential yield (bales/ha) and variability of yields, expressed in terms of probability of exceedence.

| Region      | 200mm Plant Available Soil Water |     |     | 250mm Plant Available Soil Water |     |     |
|-------------|----------------------------------|-----|-----|----------------------------------|-----|-----|
|             | Mean                             | 80% | 20% | Mean                             | 80% | 20% |
| Gunnedah    | 3.2                              | 2.5 | 4.0 | 4.0                              | 2.9 | 4.9 |
| Wee Waa     | 3.4                              | 2.3 | 4.6 | 4.2                              | 2.7 | 5.2 |
| Bellata     | 3.6                              | 2.6 | 4.6 | 4.3                              | 3.1 | 5.4 |
| Moree       | 3.3                              | 2.4 | 4.3 | 3.4                              | 2.5 | 4.2 |
| Croppa Ck   | 3.3                              | 2.3 | 4.5 | 4.3                              | 3.1 | 5.9 |
| Goondiwindi | 3.4                              | 2.3 | 4.3 | 3.6                              | 2.8 | 4.3 |
| Dalby       | 3.2                              | 2.2 | 4.0 | 4.0                              | 2.7 | 5.2 |
| Biloela     | 3.4                              | 2.6 | 4.0 | 4.2                              | 3.3 | 5.1 |
| Emerald     | 3.4                              | 2.4 | 4.2 | 4.1                              | 3.1 | 5.2 |

historical records has been using the Southern Oscillation Index (SOI). The SOI is an index of the difference in atmospheric pressure between Darwin and Tahiti. It is a key indicator of the El Niño – Southern Oscillation (ENSO) phenomena. At present, we divide seasons into five groups, depending on the value and the rate of change of the SOI (SOI phase) at the time of forecast. The SOI phase is derived from the change in the SOI from last month to the SOI value at the time of the forecast. Phase I – SOI is consistently negative; phase II – SOI is consistently positive; phase III – SOI shows a rapid fall; phase IV – SOI shows a rapid rise; phase V – SOI is consistently near zero. Every month of the past 120 years has been categorised into one of the five phases that takes into account the value and change in SOI.

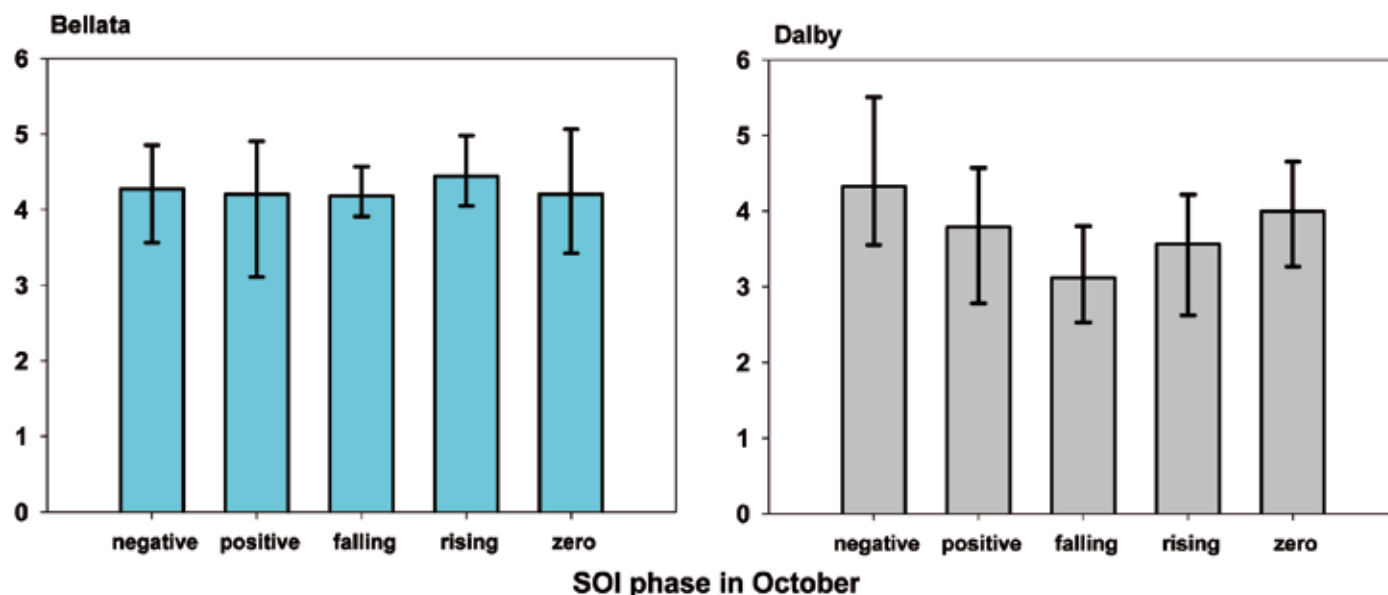
**TABLE 6.**

OZCOT predictions, *single skip* row configuration – effects of sowing date on potential yield (bales/ha) and variability of yields, expressed in terms of probability of exceedence.

| Region               | 15 Sep | 30 Sep | 15 Oct | 30 Oct | 15 Nov | 30 Nov | 15 Dec | 30 Dec |
|----------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>Central Qld.</b>  |        |        |        |        |        |        |        |        |
| Mean                 | 3.2    | 3.6    | 3.5    | 3.5    | 3.6    | 3.4    | 2.9    | 3.2    |
| 80%                  | 2.4    | 2.6    | 2.6    | 2.6    | 2.7    | 2.4    | 2.1    | 2.4    |
| 20%                  | 4.0    | 4.4    | 4.5    | 4.4    | 4.5    | 4.5    | 3.6    | 4.0    |
| <b>Darling Downs</b> |        |        |        |        |        |        |        |        |
| Mean                 | 3.0    | 3.5    | 3.4    | 3.6    | 3.3    | 2.6    | 1.5    | 3.0    |
| 80%                  | 2.1    | 2.3    | 2.4    | 2.4    | 2.3    | 1.7    | 0.4    | 2.1    |
| 20%                  | 4.3    | 4.4    | 4.2    | 4.6    | 4.2    | 3.6    | 2.3    | 4.3    |
| <b>Macintyre</b>     |        |        |        |        |        |        |        |        |
| Mean                 | 3.0    | 3.1    | 3.2    | 3.3    | 3.5    | 3.2    | 2.1    | 3.0    |
| 80%                  | 2.1    | 2.0    | 2.2    | 2.6    | 2.7    | 2.1    | 1.4    | 2.1    |
| 20%                  | 3.6    | 3.8    | 3.9    | 4.2    | 4.1    | 4.0    | 2.7    | 3.6    |
| <b>Gwydir</b>        |        |        |        |        |        |        |        |        |
| Mean                 | 2.6    | 3.1    | 3.3    | 3.4    | 3.2    | 2.7    | 1.6    | 2.6    |
| 80%                  | 2.1    | 2.3    | 2.2    | 2.4    | 2.4    | 2.0    | 0.6    | 2.1    |
| 20%                  | 3.3    | 3.8    | 4.4    | 4.4    | 4.1    | 3.5    | 2.5    | 3.3    |
| <b>Lower Namoi</b>   |        |        |        |        |        |        |        |        |
| Mean                 | 2.8    | 3.3    | 3.4    | 3.4    | 3.4    | 2.7    | 1.5    | 2.8    |
| 80%                  | 1.8    | 2.1    | 2.4    | 2.5    | 2.3    | 1.8    | 0.4    | 1.8    |
| 20%                  | 4.1    | 4.5    | 4.4    | 4.7    | 4.3    | 3.5    | 2.4    | 4.1    |
| <b>Upper Namoi</b>   |        |        |        |        |        |        |        |        |
| Mean                 | 2.7    | 3.0    | 3.1    | 3.1    | 3.0    | 2.0    | 0.9    | 2.7    |
| 80%                  | 1.9    | 1.9    | 2.1    | 2.3    | 2.1    | 1.1    | 0.0    | 1.9    |
| 20%                  | 3.9    | 3.9    | 4.2    | 3.9    | 3.7    | 2.6    | 1.7    | 3.9    |

**FIGURE 4.**

Forecasted average dryland cotton lint yields (simulated using OZCOT using the details previous page for a 250mm plant available soil water profile) for single skip row configurations at Bellata (NSW) and Dalby (Qld) across for different phases of the SOI in October. The bottom of the error bar is the 80% probability of exceedence, while the top is the 20% probability. For a 200mm plant available soil water profile, average yields are less than for a 250mm profile and there is considerable more variability estimated for the negative, positive and zero phases. Average yields are considerably less for the rapidly falling and rising phases, but have less variability.



Crop models can be linked with climatic data to help assess potential yields and risks of production in different years. Similar to seasonal rainfall, estimates of cotton yield for each year in a climate record can also be associated with the SOI phase at the time of forecast such as land preparation or sowing time. Simulation models such as OZCOT, when used in conjunction with the SOI can therefore provide opportunities for growers to tailor their management decisions more appropriately to potential impending seasonal conditions. Information of this nature has been used successfully to assist wheat growers in Southern Queensland in their variety choice and nitrogen management based on expected rainfall and predicted risk of frost.

Figure 4 illustrates how using OZCOT with analogous (similar) years of SOI phases in October identified from the historical climate records can be related to yield in the forthcoming season. It shows that compared to Dalby, Bellata is less affected by SOI and that average yield is slightly better when SOI is rising. For Dalby average yield is best when SOI is negative (but highly variable) and less when SOI is falling. In addition to row configuration as an option to reduce risk, other management options could also be considered. One of these is nitrogen fertiliser management. In those years where the SOI phase is associated with potentially higher yields, more nitrogen could be applied to take advantage of the opportunity. Conversely, when the conditions were less favourable, lower inputs of fertiliser may reduce possible financial losses.

## Conclusions

It is important to note that these analyses act only as a general guide to the potential yield and risks of dryland production for different regions. The outcomes and interpretation may change depending on a number of farm specific factors, for example: soil water holding capacity, starting soil moisture and costs. Most benefit comes from simulating growers' specific conditions using their own soil type and costs. Further comments on management and financial considerations of dryland cotton and different row configurations in dryland cotton production follow in this manual.

The growing of dryland cotton is subject to relatively large risk, not only in achieving yields but also because costs are a high proportion of income. Therefore the potential and risks associated with dryland production need to be calculated. Crop simulation models such as OZCOT provide a useful tool to help evaluate the risk.

### Sources of information:

Whopper Cropper risk management software can compare the effects of different management options to help farmers to better manage production and economic risks. <http://www.backpaddock.com.au/WhopperCropper.aspx>

HowWet is a Windows based program that provides a simple method of using rainfall records to estimate storage of rainfall in the soil. <http://www.apsim.info/How/HowWet/how%20wet.htm>

Rainman StreamFlow software enables users to analyse detailed historical climate data and predict rainfall at a specific location within a specified time period. <http://lwa.gov.au/products/ec030612>

The Bureau of Meteorology is Australia's national weather, climate and water agency, providing regular climate forecasts, warnings, monitoring and advice – [www.bom.gov.au](http://www.bom.gov.au)

### Reference

Bange, M.P., Carberry, P.S., Marshall, J. and Milroy, S.P. (2005) Row configuration as a tool for managing rain-fed cotton systems: Review and simulation analysis. *Australian Journal of Experimental Agriculture* 45(1): 65–77.



# Crop economics

By **FIONA SCOTT & JANINE POWELL**,  
I&I NSW



Fiona Scott.



Janine Powell.

## Finance

Financing the crop is a major consideration. Crop credit is available through agricultural chemical resellers and allows growers the option of deferring chemical costs until after picking. Interest is charged at current short term money market rates, e.g bank bill rates.

At picking, pre-ginning loans (module advances) are available from most ginners and merchants. Details should be discussed with your merchant.

Timing of payment for cotton lint depends on the type of contract. Cash contracts are generally paid within 14 days of ginning, whilst 'Pool' contracts may pay up to 75 percent in July (after ginning) with further payments in September and December. Confirm with your accountant and merchant about the best payment structure for your business prior to entering into any contracts.

## Gross margin budgets

A gross margin represents the difference between gross income and the variable costs of producing the crop. Gross margin budgets provide a guide to the relative profitability and an indication of the management operations involved in different enterprises.

Gross margins do not take into account risk or farm profit.

## Risk

Gross margins can show the proportion of costs in relation to income, but don't consider price and yield risk. The following sensitivity charts help to illustrate the effect that changes in yield and cotton lint prices have on gross margins.

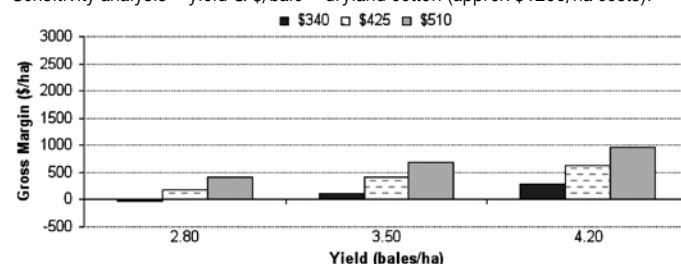
## BE AWARE OF

- Budgeting is essential. Do not rely on published budgets as they will not reflect the growing situation for your farm, instead use them as a guide to create your own budgets.
- Gross margins can show the proportion of costs in relation to income, but they don't consider price and yield risk.

These sensitivity charts reflect the resulting changes to crop gross margins from a 20% change in both typical yields & long term average prices. **The charts emphasise that the profitability of a cotton crop is highly sensitive to both changes in yield and the cotton lint price, highlighting the importance of using achievable figures in the budgeting process.** The range of potential yields and prices is much wider than depicted, however it is the relationship between yield, price and the effect they have on gross margins which is important.

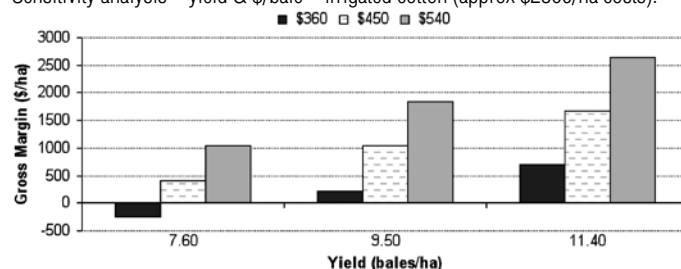
**FIGURE 1.**

Sensitivity analysis – yield & \$/bale – dryland cotton (approx \$1200/ha costs).



**FIGURE 2.**

Sensitivity analysis – yield & \$/bale – irrigated cotton (approx \$2800/ha costs).



Gross margin budgets do not show gross **farm profit** because they do not include fixed or overhead expenses such as depreciation on machinery and buildings, interest or insurance payments, rates, taxes or permanent labour which have to be met regardless of crop type. The amount of fixed costs per hectare varies considerably between properties, making it difficult to provide useful representative estimates of such costs.

Industry & Investment NSW develop gross margin budgets for crops, vegetables and livestock annually at <http://www.dpi.nsw.gov.au/agriculture/farm-business/budgets>

Individual budgets are provided in Portable Document Format (PDF). To read these files you need to have Adobe Acrobat Reader installed on your computer.

Budgets are calculated using crop yields for the region that are consistent with the operations given, current commodity and input prices and technical information provided by agronomists and cotton industry development officers.

The degree to which these budgets reflect actual crop returns will be influenced not only by general factors common to all farms, such as prices and season conditions, but also by the individual farm characteristics such as soil type, crop rotation, and management.

Consequently, it is strongly recommended that published gross margin budgets be used as a **GUIDE ONLY** and

should be changed to take account of movements in crop prices, changes in seasonal conditions and individual farm characteristics.

Refer to the Industry and Investment website (<http://www.dpi.nsw.gov.au/agriculture/farm-business/budgets>) Download: 'Farm forms – crop') for downloadable specialised cotton budget forms in Excel format.

Gross margins need to be used carefully when using them as a guide to deciding on the farm's overall enterprise mix. Because overhead costs are excluded, it is advisable to only make comparisons of gross margins between enterprises which use similar resources (i.e labour).

If major changes are being considered, more comprehensive budgeting techniques (that include overhead costs) are required to indicate the real profitability situation.

Assumptions used for the Industry & Investment gross margins include:

- Average cotton yields from the previous season.
- An average to high number of insecticide applications using a soft approach to maintain predators (listing of brand or chemical names in the budgets does not imply a recommendation of those brands/ chemicals).
- Selection of pesticide varies markedly depending on pest species and season. Rotation of insecticides should be followed as per industry strategy, which changes each year due to changes in insect resistance to chemicals (see pest management guide for details).
- Source of water is from the river using a diesel pump.
- 7ML of irrigation water is the volume applied to the crop in field (system losses & tail water not accounted for).
- Machinery costs refer to the variable costs of fuel, oil, repairs and maintenance for both the tractor and the implement. For details on variable and overhead cost calculations refer to Industry & Investment's Guide to machinery and water costs at <http://www.dpi.nsw.gov.au/agriculture/farm-business/budgets> and the 'Guide to machinery costs and contract rates' (Primefact 913) on the same site.
- All prices are those estimated in the August prior to planting.

Table 1 below is an example of a simple gross margin. The budget lists income sources, cost items and totals, with gross margin calculated as the total income less total costs. These figures are an indication only, and may not reflect your personal situation. For more detailed cotton budgets, see the following websites;

Industry & Investment NSW:

PDF Summer Gross Margins: <http://www.dpi.nsw.gov.au/agriculture/farm-business/budgets/summer-crops>

Downloadable Gross Margin template: [http://www.dpi.nsw.gov.au/\\_\\_data/assets/file/0008/195641/FF-crop2009.xls](http://www.dpi.nsw.gov.au/__data/assets/file/0008/195641/FF-crop2009.xls)

Cotton Seed Distributors:

Gross Margin Analysis: <http://www.csd.net.au/page/show/21113/>

Dryland cotton overview (including gross margin comparisons for various row configurations)

<http://www.csd.net.au/asset/send/2283/inline/original/>

**TABLE 1.**

Example summary gross margin @ \$550/bale. Use this Gross Margin budget as a guide to create your own budget reflecting your operations, yield estimates and current pricing.

| <b>IRRIGATED COTTON (Roundup Ready Flex™ Bollgard II®)</b> |                  |
|------------------------------------------------------------|------------------|
| <b>Income</b>                                              |                  |
| 9.5 bales/ha @ \$550/bale                                  | \$ 5225          |
| 2.95 t/ha seed @ \$240/tonne                               | \$ 708           |
| <b>TOTAL INCOME (A)</b>                                    | <b>\$ 5933</b>   |
| <b>Variable Costs</b>                                      |                  |
| Cultivation                                                | \$ 12.00         |
| Seed and sowing                                            | \$ 97.00         |
| Fertilisers                                                | \$ 626.00        |
| Herbicides                                                 | \$ 128.00        |
| Insecticides                                               | \$ 53.00         |
| Defoliant                                                  | \$ 87.00         |
| Boom applications                                          | \$ 13.00         |
| Aerial applications                                        | \$ 68.00         |
| Irrigation 7ML (C)                                         | \$ 287.00        |
| Insurance                                                  | \$ 55.00         |
| Consultant                                                 | \$ 60.00         |
| Licence fees                                               | \$ 390.00        |
| Contract harvesting                                        | \$ 285.00        |
| Module lifting                                             | \$ 28.00         |
| Cartage                                                    | \$ 83.00         |
| Ginning                                                    | \$ 523.00        |
| Levies                                                     | \$ 43.00         |
| Stalk pull & mulch                                         | \$ 75.00         |
| Pupae Busting & Bed Renovation                             | \$ 60.00         |
| Refuge (Pigeon Pea 5%)                                     | \$ 23.00         |
| <b>TOTAL VARIABLE COSTS (B)</b>                            | <b>\$ 2,996</b>  |
| <b>GROSS MARGIN/HA (=A-B)</b>                              | <b>\$ 2,937</b>  |
| <b>GROSS MARGIN/ML (=A-B)/C)</b>                           | <b>\$ 420</b>    |
| <b>Pigeon Pea Refuge Crop (assumed costs)</b>              |                  |
| Seed & Sowing                                              | \$ 76.00         |
| Herbicides                                                 | \$ 153.00        |
| Boom applications                                          | \$ 7.00          |
| Irrigation                                                 | \$ 112.00        |
| Slashing                                                   | \$ 12.00         |
| Cultivation                                                | \$ 107.00        |
| <b>Variable Costs per ha of pigeon pea</b>                 | <b>\$ 467.00</b> |





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# Machinery requirements

By **PETER HUGHES, DEEDI**

Machinery is an important consideration for new cotton growers. There are some operations such as spraying and picking that can be done by a contractor. In some seasons the demand for these services is going to be great and the availability limited. Examine the cost of not doing the job on time versus the cost of financing new equipment.

Before purchasing new equipment, look at the existing equipment already on the farm and see what can be used or modified to suit. For example, most conventional broad acre boom sprayers can be cheaply modified to successfully spray cotton. Planting equipment used for summer crop planting of sunflower or sorghum should be adequate. A toolbar is quite easy to modify or build for inter-row weed control. Lay-by chemicals can be applied with conventional spray equipment by selecting different nozzles and reducing spray pressures.

Alternatively it may be possible to cooperate with a neighbour in some operations.

Determine how much time is available to complete the task and then compare this with the existing capacity to do the job.

**BE CAREFUL** – most people overestimate a machine's capacity.

## Acceptable time periods to complete various tasks

- Planting – 7 days
- Spraying – 2 days
- Inter-row cultivate – 7 days
- Harvest – 21 days

## Typical machinery requirements for 200–400ha of cotton

- Tractor (150kW)
- Planter – 8 row (12m)
- Spray Rig – 24m
- Nurse Tank – 8000 litres
- Inter-row Cultivator – 12m
- Slasher
- Module Tarps (100) + Cotton Ropes

## BE AWARE OF

- Minimise cost by modifying and adapting existing equipment.
- Check availability of contractors.
- Match work rates to the area planted.

## Work Rates

- Planting 6ha/hr
- Spraying 16ha/hr
- Picking: Stripper – (4 row) 2.4ha/hr  
Spindle – (4 row) 1.2ha/hr

## Tractors

While all types of tractors are being successfully used on cotton farms, the Front Wheel Assist design is becoming very popular. This design is ideally suited to a row crop situation because:

- Larger percentage of weight over the front axle gives better stability when using heavy 3pt linkage equipment.
- Larger diameter front tyres can carry large spray tanks with less damage to axle and tyres.
- Front tyres can be operated at lower pressure and therefore help reduce soil compaction.
- Better tractive efficiency allows more engine power to be utilised at the drawbar.

While this type of tractor has many advantages over 2WD, major inefficiencies can occur if the tractor is operated with insufficient lead on the front tyres. The front tyre must run 2–5% faster than the rear tyre. The lead is altered by changing the weight distribution front to rear, increasing or decreasing tyre pressures and the fitment of dual tyres.

Common symptoms of incorrect lead are:

- Excessive wear on the rear tyres;
- A rough ride;
- The tractor running easier when in 2WD; and,
- Leaking front differential seals.

More details on assessing lead are contained in the Qld DPI publication Tractor Performance Handbook.

If alterations have been made to the tractor's original set-up then at least check that the weight split is 40% front: 60% rear and the front tyres pressures are at least 30kPa higher than the rear tyres.

## Planting machinery

Planting machines need to be able to meter the seed accurately and place the seed consistently at depths no greater than 5cm.

## Deep planting MUST BE AVOIDED

Precision planters are becoming more common in dry land cotton. Problems have been encountered when double disc openers have been used on uneven, wet seedbeds.

When planting into raised beds the double discs are kept free from a build up of mud because of the dry crust on the surface. When planting 'on the flat', wet spots in the field can cause mud build up and as a result may require planting to be delayed. While precision planters are preferable, combines and air seeders have given satisfactory results. A press wheel is required with all



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machines and pressures similar to that for sunflower are necessary (1–2kg/cm width).

Improvements to the metering/placement accuracy for both combines and air seeders can be attained by:

- Rotating the fluted/peg roller at the maximum speed while exposing as little of the roller as possible to achieve the desired seedling rate.
- Replacing older convoluted hoses with modern smooth bore hoses.
- Keeping air velocities up in the hoses leading to the distribution heads.
- Using two distributors head outlets per row.
- Ensuring adequate diffusion of air in the seed tubes leading to the planting boot. Drilling of holes in the seed tube may be necessary.
- Using a stronger planting Tyne and a small duck foot planting boot.

A compromise between the precision planter and the combine/airseeder is the press wheel planter unit that can be retro-fitted to the latter units. This type of unit improves sowing depth control and includes a press wheel. The major disadvantage of adding these units is that the extra weight at the back of the machine may cause problems especially in lifting.

Hilling up is not necessary for dry land cotton planting

but some hilling during inter-row cultivation can improve harvesting. It provides a shallow furrow for the picker wheels allowing the picking closer to the ground.

### Moisture seeking

Removing the surface layer of dry crusted soil may allow the seed to be placed into moisture at the correct depth. While this technique allows for timely planting it may help to concentrate chemicals in the furrow if a heavy rainfall event occurs. If soil is washed back into the furrows immediately after planting, seedling establishment time will be increased and seedling vigour decreased due to the increased depth from which seedlings must emerge.





# On-farm energy use

By **CRAIG BAILLIE**, NCEA



On-farm energy efficiency is becoming increasingly important in the context of rising energy costs and concern over greenhouse gas (GHG) emissions. Energy inputs represent a major cost and one of the fastest growing cost inputs to primary producers. The Australian cotton growing industry is highly

mechanised and heavily reliant on fossil fuels (electricity and diesel). Within highly mechanised farming systems such as those used within the cotton industry, machinery inputs are significant and can represent 40–50% of the cotton farm input costs. Direct energy use is a major component of these costs. Given the major dependence on direct energy inputs and rising energy costs, energy use efficiency is an emerging issue for the Australian cotton industry.

Previous work undertaken by the National Centre for Engineering in Agriculture (NCEA) has studied direct on farm energy use involving a number of case study cotton farms to understand the range, costs and contributions of energy use to cotton production and greenhouse gas emissions. The results from this work showed that

## BE AWARE OF

- Record farm energy usage to identify how efficiently energy is used and where the most energy is consumed.
- Explore ways to reduce energy use by focusing on high energy input areas and investigate opportunities to reduce energy inputs by changing practice or by doing the same operation more efficiently.
- Identifying ways to reduce energy consumption can pay for itself in real dollar terms and is one of the cheapest and fastest ways to reduce greenhouse gas emissions.
- Modifying the operation of machinery and equipment incorrectly (i.e. causing harm to diesel engines; pumping equipment).
- Poorly targeted investment or changes to on farm practices (i.e. on farm improvements need to be informed by an objective assessment of energy savings with sufficient detail to achieve desired outcomes).

For further information and support relating to assessing your energy and greenhouse gas emissions, refer to the energy and greenhouse gas module in *myBMP* ([www.mybmp.com.au](http://www.mybmp.com.au)).

energy use varies depending on the cropping enterprise and the farming system and that there are significant opportunities to reduce energy and costs. In comparison the GHGs from direct energy use can be similar and in fact greater than the GHGs generated by soil/fertiliser/water interactions. Improving on farm energy use would appear to be as important as improving nitrogen efficiency.

In the cropping sector a number of practice changes and technology developments have been, or are being, adopted which can be expected to reduce fuel/energy use or energy use intensity. Examples include minimum/zero tillage, controlled traffic, a range of precision ag technologies, planting of GM crops, some water use efficiency measures and use of legumes in crop rotations.

Within highly mechanised agricultural productions systems such as the Australian cotton industry direct energy inputs (i.e. diesel and electricity) represent a major cost to the grower and potentially a significant proportion of the total GHG emissions. Previous studies have reported significant savings in energy for both a refinement in current practices (i.e. up to 30% for individual operations) and a change in practice (10–20% across the farming system) through energy assessment.

Rational and efficient use of energy is essential for sustainable development in agriculture. At the current market condition, 1 Gigajoule (GJ) of energy would typically cost Australian farmers \$20 to \$25. Previous work including irrigated cotton production has shown that total energy inputs are influenced by management and farming methods, and ranged from 3.7 to 15.2 GJ/ha; at a cost of \$80 to \$310/ha and 275 to 1404 kg CO<sub>2</sub> equivalent/ha greenhouse gas emissions. Dry land cotton production in comparison is expected to be at the lower end of this range.

## Assessing on farm energy use

An energy assessment is the systematic examination of a farming enterprise to determine whether, and to what extent, it has used energy efficiently. An energy assessment determines how efficiently energy is being used, identifies energy and cost saving opportunities and highlights potential improvements in productivity and quality.

This may also include potential energy savings through fuel switching, tariff negotiation and managing energy demands. Practically the main purpose of conducting energy assessments and maintaining records is to identify opportunities for significant cost savings which will lead to reduced GHGs.

The concept of energy assessments in the cotton industry is relatively new with ongoing work being continued within the industry and linkages to myBMP. Specifically for agriculture, a methodology supported by the software, EnergyCalc ([www.kmsi.ncea.biz](http://www.kmsi.ncea.biz)) has been developed by the National Centre for Engineering in Agriculture to undertake agricultural energy assessments. EnergyCalc also converts direct

energy inputs into greenhouse gas emissions. Both the methodology and software requires some instruction however a record of farming practices and equipment or detailed bowser and electricity meter-box type measurements for all farming operations form the basis of an energy assessment. The methodology and terms used to describe different levels of energy assessments are discussed below. It is noted that the system suggested above for agriculture is similar to that used within the building industry (Australian/New Zealand AS/NZS 3598:2000). However, some differences do occur at the detail in which some measurements are conducted. This is mainly because:

- Agriculture is significantly influenced by seasonal factors and the energy use profile for agriculture may vary on both an annual and daily basis.
- Much more diverse types of machinery are used in agriculture and different machines may be used at different times.
- Fuel use, rather than electricity, is most important for agriculture.

### **Preliminary assessment**

#### **(Overview of the total energy consumption on-site, whole farm approach)**

This is the simplest and cheapest form of energy assessment and is referred to as a preliminary assessment or overview of the whole farm. This involves collating all the energy use data from the farm, including the total fuel (diesel, petrol and other fuels) and the total electricity energy consumed. It is generally expected that these figures will be available from the farm receipts. The total energy uses are then divided by the total farm production (e.g., head of cows; bales of cotton; tonnes of wheat) or area. This is done for comparative purposes which assist in identifying the relative significance of opportunities for improvement. In addition this approach also allows for an assessment of the full cropping cycle where multiple crops are grown in rotation. Usually no additional tools are required for this level of assessment. The main purpose of a preliminary assessment is to benchmark overall energy consumption for comparing the relative performance of similar enterprises and identifying high energy use.

### **Standard/general assessment**

#### **(Itemised farm approach, practice based)**

A standard/general assessment is effectively a practice based assessment which includes a desktop study of the energy breakdown or itemised account of energy usage across the farm. Energy usage for key farming processes is determined from data easily available from the site (i.e. record of practices, some fuel use data), calculated from machine specifications or based on published data for specific farming practices. A standard/general assessment aims to reach an accuracy of  $\pm 20\%$ , the purpose of which is to target further investigation. Site specific information including electric motor sizes,

pumping equipment, tractors and vehicles is collated to calculate energy use.

### **Advanced assessment**

#### **(Itemised farm approach, measurement based)**

An advanced assessment is a comprehensive measurement based assessment/study of energy usage for different practices across the farm. An advanced assessment utilises site specific data either gained from on-site measurement or through data/records maintained over time. An advanced assessment generally aims to reach an accuracy of  $\pm 10\%$  to qualify energy use also leading to further investigation. For an advanced assessment the process is similar to a standard/general assessment. An advanced assessment may include simple record keeping or more sophisticated equipment to extract energy usage for specific items of plant. Measurements would normally include bowser and electricity meter-box type measurements for all farming operations and processes.

### **Detailed assessment of high energy use farming practices (Specific operation investigation)**

The aim of a detailed assessment is to investigate ways to improve the efficiency of a specific operation and most likely require specialised advice. Ideally this would focus on where the greatest energy consumption has been identified from standard or advanced assessments. This will usually involve a range of different sensors to measure the performance (energy efficiency) of different machinery. Examples of sensors used may include pressure (irrigation head pressure), flow rate, engine RPM, tractor travel speed, torque, load and temperature etc. A data logger may be required to record data for a considerable period of time to determine performance and to identify optimised machine settings (i.e. pumping). Detailed assessments of specific tractor based operations have identified potential savings in diesel use of 30% can be achieved depending on how the tractor is operated. Tractor Performance Monitors (TPM) which are standard features in most modern tractors are useful for choosing the appropriate gear and engine speed that maximises fuel efficiency.

### **Assessing greenhouse gas emissions (GHGs) from direct energy inputs**

With the increased community concern on global warming and climate change, the greenhouse gas emissions from the fuel use of agricultural production can be easily determined. This is particularly important in highly mechanised production systems as direct energy use contributes a significant proportion of the total GHGs and may be similar to biologically generated emissions (i.e. soil/water/fertiliser interactions). This may have strategic use to the cotton industry in the future through product labelling or where a price on carbon is established. Conversion of direct energy use (i.e. fuel, electricity etc) to greenhouse gas emissions can



be determined by calculations and factors outlined in the Australian Greenhouse Office (AGO) Factors and Methods workbook (2008) and presented in Table 1.

**TABLE 1.**  
CO<sub>2</sub> Emission factors.

| Energy sources | Emission Factor kg CO <sub>2</sub> equivalent per litre diesel/ petrol/LPG or per kWh electricity |
|----------------|---------------------------------------------------------------------------------------------------|
| Diesel         | 2.9                                                                                               |
| Petrol         | 2.5                                                                                               |
| LPG            | 2.56                                                                                              |
| Electricity    | 1.04                                                                                              |

These calculations and factors are contained in EnergyCalc ([www.kmsi.ncea.biz](http://www.kmsi.ncea.biz)) and other software available to the cotton industry such as the Cotton Greenhouse Gas Calculator developed by Dr Peter Grace, QUT (<http://www.isr.qut.edu.au/tools/index.jsp>).

## On farm energy use & GHGs

Previous work has shown that on farm energy use varies significantly between different farming enterprises, with on farm energy use ranging from 3.7 to 15.2 GJ/ha costing \$80 to \$310/ha. All farms included in the study covered a range of farming regions and farming practices (e.g., conventional tillage, minimum tillage, dryland farming, and irrigation) in both NSW and Queensland. Diesel energy inputs ranged from 95 to 365 litres/ha, with most farms using 120 to 180 litres/ha.

GHGs associated with this direct energy use was estimated to be between 275 and 1404 kgCO<sub>2</sub>-e /ha. Dry land cotton production is expected to be at the lower end of this range. It is important to note that these calculations only relate to GHGs from direct energy use, and has not included the (biological) effect due to soil tillage/disturbance and applications of nitrogen fertiliser which can be determined by the Cotton Greenhouse Gas Calculator.

For irrigated cotton, average energy related greenhouse gas emissions can be equivalent to emissions from fertiliser use. A focus on improving on-farm energy use efficiency can be as important in irrigated cropping systems as improving nitrogen use efficiency. For example, data contained in the Australian Government's submission to the UN Framework Convention on Climate Change May 2010 suggests that, in irrigated cotton, average energy related costs and greenhouse gas emissions (0.712 t CO<sub>2</sub>-e/ha) appear to be equal to average costs and emissions from fertiliser use (0.67 t CO<sub>2</sub>-e/ha).

## Energy saving practices

Generally lower energy use on farm is a function of the number and intensity of farming operations and the requirements for pumping irrigation water. In cotton systems, water pumping is often the major energy use

operation (20–70%). Several more detailed examples show that significant efficiency gains (and in some cases crop productivity gains) can be made by optimising pump performance to provide reductions in diesel costs and in some cases improved pump efficiency can lead to increased water flow, more timely irrigation and improved crop yield.

It has been shown that if a farmer moves from conventional tillage to minimum tillage, there is a potential saving of around 10% of the fuel used on the farm, plus other production advantages. It has also been found that energy use associated with picking is also significant and may contribute 20–50% of the total direct energy use (more so in dry land cropping systems).

In 2009 the NCEA conducted a case study to benchmark the energy use reductions resulting in the adoption of reduced tillage systems on the cotton farm 'Keytah' in the Gwydir Valley. The study showed that adoption of a minimum tillage system had reduced energy costs (and greenhouse emissions) by 12% since 2000 and developing a 'near zero till' system had the potential to reduce this to 24% less than 2000 energy costs. The integration of diesel-gas systems to reduce reliance on diesel fuel on this farm also shows considerable promise.

Compared with cotton, the energy use of other rotational (grain) crops is usually lower. Cotton generally has a greater number of farming operations, more intensive energy use associated with harvest (i.e. picking) and higher irrigation demands.

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# Precision Agriculture in cotton farming systems

By **ANDREW SMART & BROOKE SAUER**



Cotton growers in Australia are not only familiar with the term Precision Agriculture (PA), but are also very familiar with the concepts, solutions, and products that are available. Justifiably, PA is often described in terms of the primary enabling technologies, the Global Positioning System (GPS), and Geographic Information Systems (GIS). However, for the PA practitioner, mastery of the technology is only a small part of a successful on-farm implementation.

Broadly, PA refers to productivity enhancing concepts such as tractor and machine control, site-specific input placement, improved product efficacy, and increased irrigation efficiency (Precision Irrigation). More specifically, we can divide PA into two main areas:

1. **Spatial Control** – this includes guidance, as well as remote monitoring and control.
2. **Spatial Agronomy and Management (SAM)** – analysis of spatial data which is decision based.

Spatial Control products have been widely adopted. In general, implementation is reasonably straightforward and benefits are easily quantifiable. SAM is more complex, requiring each value proposition to be understood at a local level. It is an agronomic and management strategy that brings together multiple data sources to allow the agronomist and manager to build

## BE AWARE OF

- PCT deliver training focussing on the interpretation of PA data and building capacity of growers & agronomists to use PA tools for agronomic decision making.
- It is rare that you can attribute in-field variability to any single factor.
- In PA, one layer of information is a good start, but multiple layers of information such as several years of yield data combined with an EM survey gives you confidence to use the information for management and agronomic decisions.

knowledge and make better crop production decisions based on in-field variability. SAM comprises 3 main steps:

1. Measurement and capture of data;
2. Interpretation and analysis of data; and,
3. Implementation of a management response.

PA has generally aided profitability in cotton farming systems by understanding and then improving the varying links between inputs (particularly water and varieties) and their interaction with soil production capabilities.

## Crop variability

Variability in cotton farming systems can be categorised as stemming from these main factors:

- **Climate** – Overall crop yields on a national level are controlled mostly by what the climate delivers. (Major events such as flooding and hail are also climate related but the outcomes of overall yield will generally only affect individual farms.)
- **Farm** – Location or valley specific incidents as previously mentioned will affect overall farm performance. Individual farm management and ownership will also impact.
- **Field** – In-field variability will be determined by a number of factors including soil types, terrain, and the impact of historical practices.
- **Agronomic** – Variety choice, pest management, irrigation timing, location of checking, and individual interpretation of events, etc.
- **Management** – Timing and type of farming practices, historical decisions, and general farm practice.

It is rare that you can attribute in-field variability to any single factor. It is far more likely that a complex relationship between several of the above factors is driving cotton production patterns. It is therefore important to consider all potential drivers in variability and to attempt to comprehensively understand what site-specific combination of factors are present.

While there are many 'tools' available to measure variability seen in cotton production systems, there are several that have proved to be consistently reliable in the majority of circumstances. These are:

- EM surveys;
- Remotely sensed images;
- Elevation maps (including derivatives such as slope and wetness maps); and,
- Yield maps.

## Measuring variability

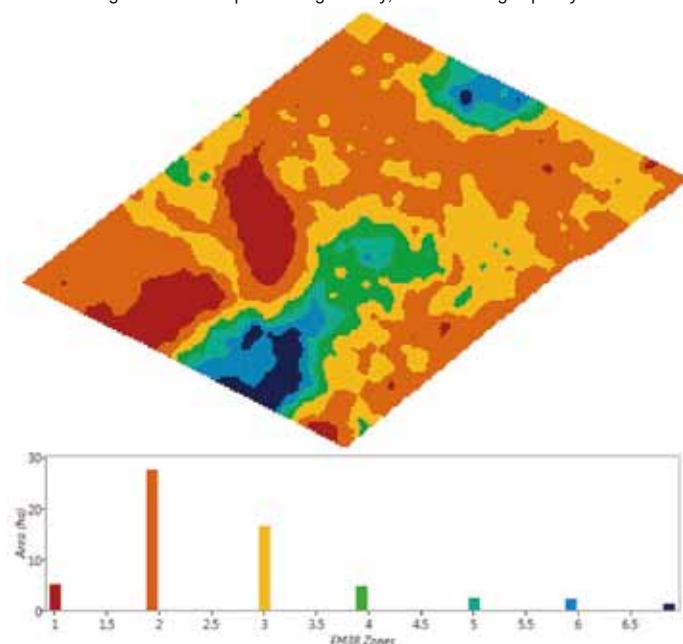
### EM soil survey

Electromagnetic induction (EM) surveys are methods of measuring apparent soil electrical conductivity (ECa) by inducing an electrical current into the soil. These surveys have become very popular for a variety of reasons,



### IMAGE 1.

EM38V survey captured with full moisture profile where red = low conductivity and blue = high conductivity. Low EM zones represent lower clay, water holding capacity and salts. High EM zones represent higher clay, water holding capacity and salts.



including speed of data gathering, interpretability, and excellent correlation with real world observations.

Soil ECa is highly correlated to a combination of soil properties including water content, clay content, and salt content. In non-saline soils ECa variations are most often a function of soil texture and moisture content. In general EM is most successfully used in areas where a single dominant factor is the cause of soil variability as recorded maps will then directly reflect that property. The main uses for EM surveys are:

- Forming soil type maps for the farm.
- Creating crop-specific yield-potential zones (all crops extract varying levels of nutrients and water from the soil).
- To Optimise location of moisture probes relative to the majority of the field.
- To direct soil sample placement to best understand subsoil limitations.
- To understand yield potential in dryland systems by relating EM and soil sample data to plant available water capacity (PAWC).
- To locate deep drainage or leakage areas in storages and channels.

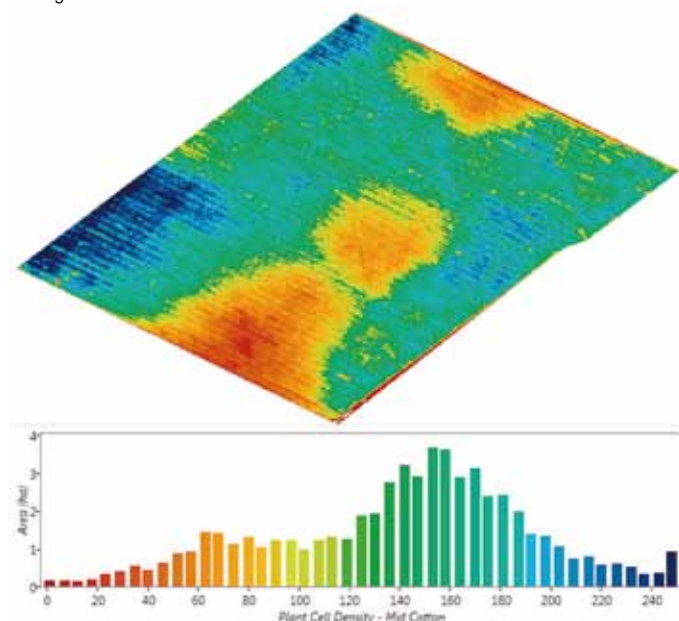
### Biomass imagery

Airborne or satellite multispectral imaging systems measure the sunlight reflected off crops. Simply put, chlorophyll containing crops have strong reflectance in the green wavelength range and low reflectance in the red and blue wavelengths.

Plant Cell Density (PCD) and Normalised Difference Vegetation Index (NDVI) are indices which use the red and near infra-red (NIR) bands and have been used extensively in cotton farming systems for:

### IMAGE 2.

Airborne imagery captured on 15th December 2002 where the relative PCD values on the X axis indicate the amount of biomass: Red = low biomass and blue = high biomass. NB. At this time in the season this map is mainly used for in crop growth management.



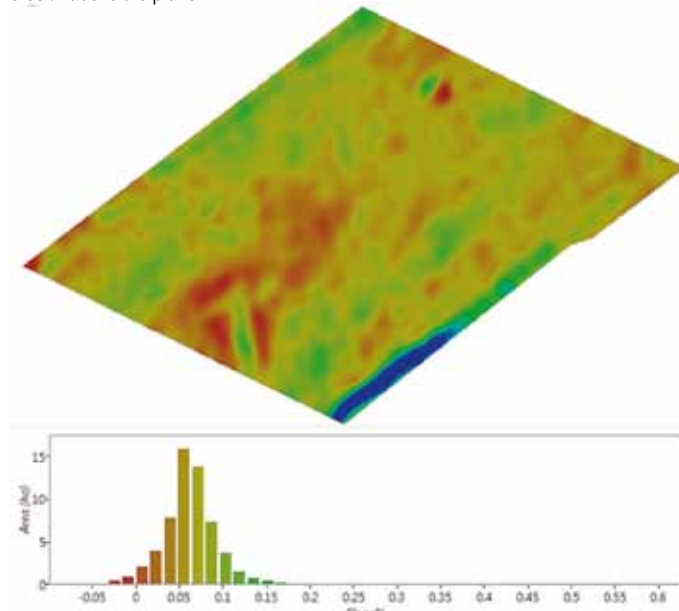
- Plant stand evaluation;
- Variable rate growth control;
- Variable rate fertiliser;
- Late season watering decisions; and,
- Variable rate defoliations.

### Elevation and landscape change

The relationship between topography, soil water infiltration, and subsequent yield is quite complex because often where terrain changes so does soil type. Topography is however a primary determinant of the

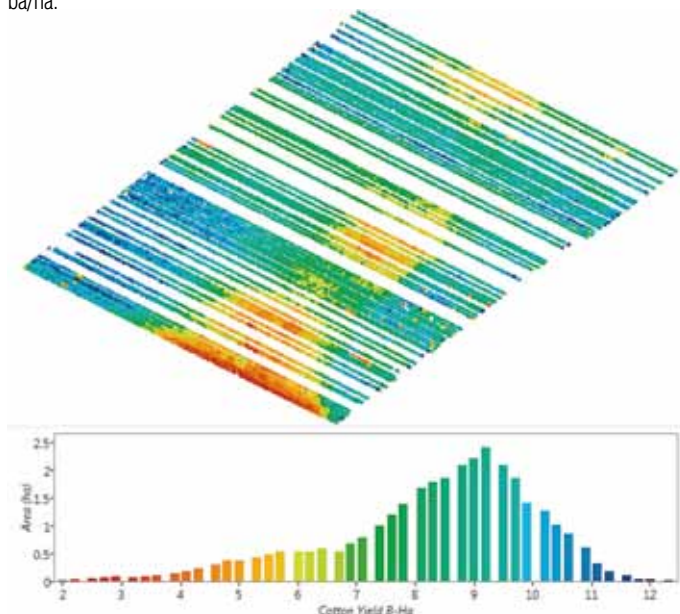
### IMAGE 3.

Slope% Map created from an RTK tractor steering system where the X axis shows soil level above or below a "plane (0)" as a percentage (i.e. 15ha of this field is 0.05% above the plane).



#### IMAGE 4.

Cotton yield from an actual cotton yield monitor, where the x axis shows yield in ba/ha.



movement of water and subsequent infiltration, and its measurement and management can yield strong benefits. Fortunately, elevation maps can be created as a by-product by most RTK tractor guidance systems.

Variations of soil type and topography combine to create differing growing environments and in the presence of subsoil constraints the relationship becomes even more complex. Elevation data coupled with EM surveys provide valuable information about the likelihood of waterlogging within irrigated fields. High EM and low elevation areas of the field will often be subject to prolonged waterlogging which has severe detrimental effects on cotton production.

The main uses for elevation data are:

- locating moisture probes to avoid to areas in the field where water may lay or shed excessively (in combination with em maps).
- Prioritising areas for remedial earthworks.
- Designing surface drainage to improve trafficability.
- Designing farm layouts to manage water flow and erosion.

#### Yield

Recording actual yield response is critical as a starting point for developing information about inherent field variability. Even if the information is merely anecdotal, it still remains as one of the simplest and most economical ways to monitor variability (and the integrated effect of environmental factors that influence yield). Recent technology improvements have enabled the accurate and effective monitoring of cotton yield. Subsequently yield monitors are becoming more commonly used in cotton pickers.

Outside of simple visual inspection, the main uses of yield maps rely on having other layers of information for combined analysis.

These analyses outcomes include:

- Determining which soil types yield highest and lowest.
- Prioritizing management efforts with respect to soil types.
- Calculating which fields or parts of field are viable for earthworks.
- Calculating yield loss from areas in dryland fields that are water logging, and therefore the viability of surface drainage.
- Overlaying in-season imagery to build knowledge of yield outcomes at certain stages of crop growth for future crops.
- Building yield-potential zones with actual yield data for more accurate pre-crop fertiliser application.
- Calculating the viability of using gypsum in dryland or irrigated fields.

Using a simple correlation analysis method we can investigate cotton yield on a zone level based on EM value. Figure 1a (page 30) shows Cotton Yield in 2002 (y-axis – left) is compared within EM zones (x-axis). In this situation the highest yielding zones are also our higher area zones (y-axis- right) and low EM zones. This indicates water was managed well in this irrigated field.

Further analysis showing profit/ha (Figure 1b) identifies areas that have made money vs. areas that have lost money – the higher EM zones (in this case investigation in the field revealed high salt levels) are negative profit but only encompass a total area of approximately 3 hectares.

Using zones rather than ha basis (Figure 1c), profit, revenue and costs are tightly aligned, but show a cumulative value for each zone based on the calculated hectares in each zone.

#### Summary

Growers all across the cotton producing regions of Australia are starting to realise the benefits of PA. For some the benefits flow quickly, while for many a lead time of data collection, analysis, and knowledge enhancement is required before realistic management plans can be implemented to manage spatial variability. Over the past decade personnel at Precision Cropping Technologies have observed and aided a wide variety of successful PA outcomes. Most agronomic solutions are, by definition, site specific, and require local knowledge and expertise. All growers are advised to discuss their ideas about PA with their agronomist.



# HARVEST WITH CUTTING EDGE PRECISION



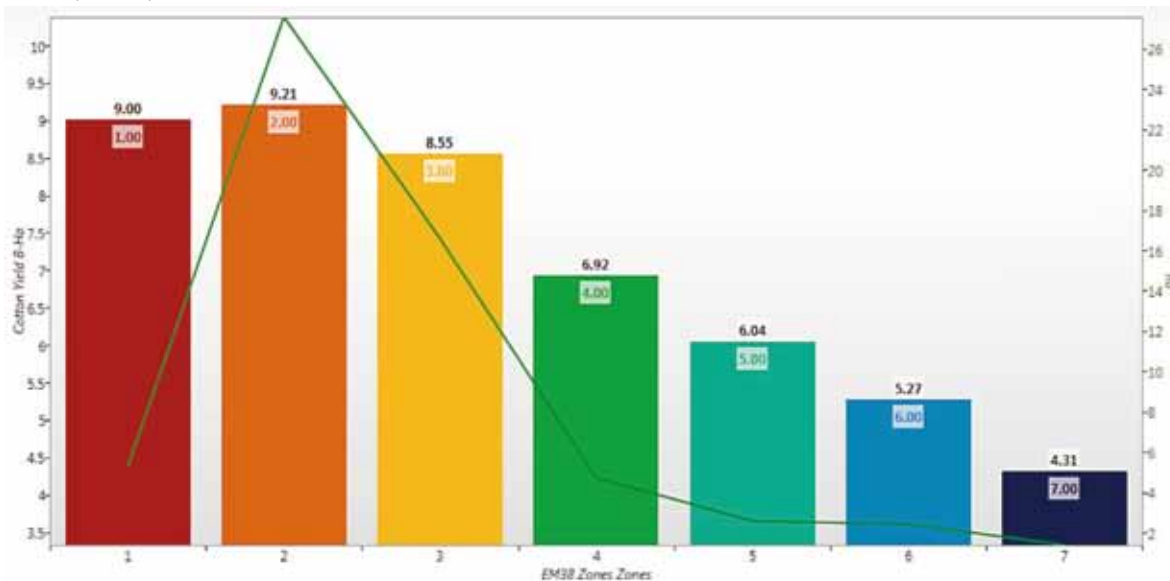
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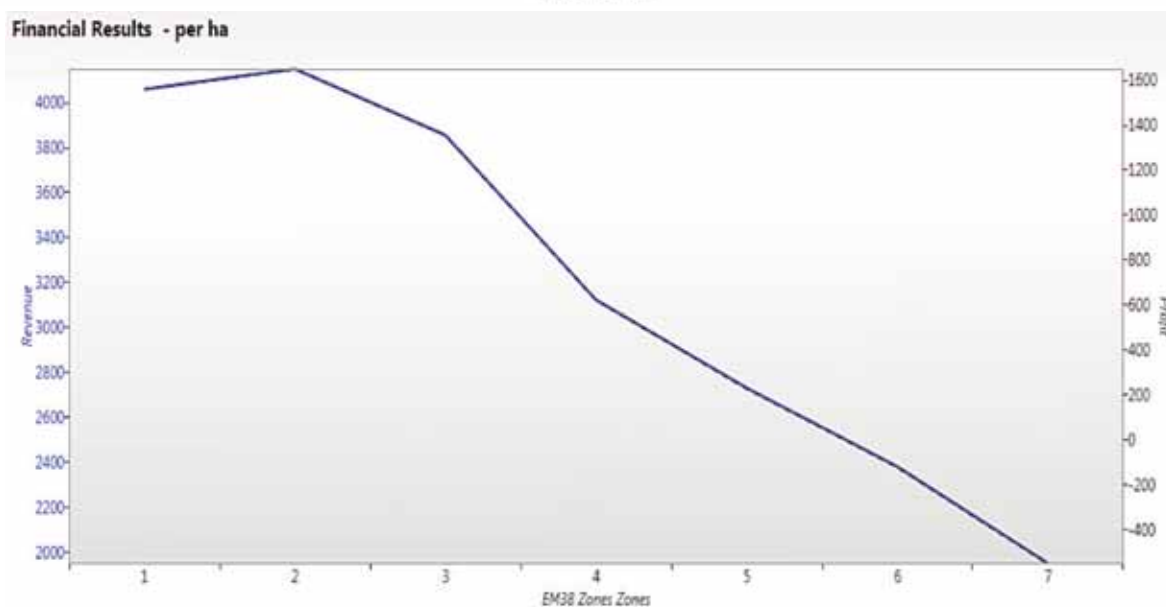
**FIGURE 1.**

Correlation between cotton yield (ba/ha) and EM zones (a), showing financial results per ha (b) and per zone (c) where revenue, costs and profits were based on receiving \$450/bale and the cost/ha was \$2500.

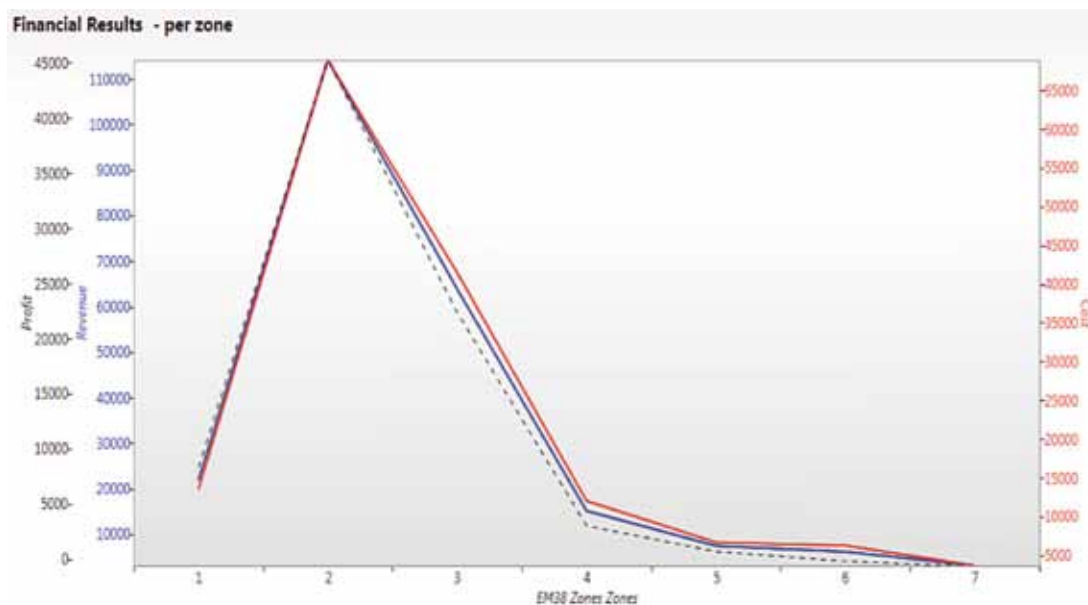
**A**



**B**



**C**





# Managing for fibre quality

By **MICHAEL BANGE, CSIRO**

Acknowledgements: Greg Constable, Stuart Gordon, Robert Long, Geoff Naylor & Rene van der Sluijs (CSIRO)



**Michael Bange.**

## Importance of quality fibre

Producing a quality fibre is important. Not only because Australian cotton holds a reputation of being purchased for a premium, but because the consequences of producing poor fibre quality is substantial (see Table 1).

In ensuring that fibre quality is maintained, it is important to understand the nature of fibre and the interacting factors that affect its quality. Optimising fibre quality starts with good crop management and selecting the right variety is a good start.

## Crop management for improved fibre quality

Fortunately the majority of crop management factors which increase/optimize yield will also increase/optimize fibre quality. One exception may be instances of high yielding crops with undesirable high micronaire cotton.

Fibre length and micronaire are significantly affected by agronomic and climate effects, however Fibre strength is more influenced by variety choice. Fibre growth and development is affected by most factors which influence plant growth. Since the fibre is primarily cellulose, any influence on plant photosynthesis and production of carbohydrate will have a similar influence on fibre growth. Cell expansion during growth is strongly driven by turgor (the pressure of fluid in the plant cell), so plant water relations will also affect fibre elongation<sup>1</sup> in the period immediately following flowering. Thus in terms

of primary (direct) responses, water status (irrigation) strongly influences fibre growth and ultimately final fibre length. Fibre elongation will also be affected by temperature and carbohydrate limitations.

Fibre thickening are also affected by temperature and radiation effects on photosynthesis with large reductions in fibre thickening leading to low fibre micronaire following long periods of low temperatures or cloudy weather. Delayed sowing may expose more of the fibre thickening phase to lower temperatures and reduce micronaire. Potassium deficiency can have a significant impact on fibre length because of the role of potassium in maintenance of cell turgor by osmotic regulation. Other nutrient deficiencies can also reduce fibre length. However where nutrient deficiencies are not the major factor in a production system, nitrogen or potassium fertiliser treatments will not necessarily improve fibre length. Early crop defoliation or leaf removal can cause substantial reductions in fibre micronaire due to the cessation in carbohydrate supply for fibre thickening. Few agronomic or climatic conditions have been shown to consistently affect fibre bundle strength.

Severe weed competition in cotton can have strong effects on fibre properties as well as trash contamination. High density and narrow row cotton production systems have variable effects on fibre quality: from no impact to significant reductions. This varied response can be explained by the specific combination of negative direct and positive indirect effects – e.g. negative impacts of competition on fibre quality may be balanced by positive effects of avoiding later unfavorable conditions. One aim of high density narrow row systems is to compress fruiting and fibre development to a shorter time period and avoid later cool or stress conditions – to at least achieve more uniform crop fibre properties.

Cotton's indeterminate growth habit also leads to many secondary (indirect) impacts of climate and management on fibre properties. Any management which delays crop maturity can lead to reduced micronaire due to exposure of a greater proportion of a crop to unfavorable conditions such as cooler or cloudy weather. Early stress with subsequent recovery, or higher nitrogen fertility and different tillage or rotation systems and insect damage causing compensation and later fruit production are examples. Therefore adoption of appropriate and efficient management (both strategic and tactical) for improving yield will also contribute to improved fibre quality. The issues to consider for each crop management phase are summarised in Table 2.

Further details on in-field management for optimum fibre quality are presented in chapters 7 to 11 in FIBREpak.

The information presented has been adapted from FIBREpak.

Further information:

FIBREpak – [http://www.cottoncra.org.au/content/Industry/Publications/Fibre\\_Quality/FIBREpak.aspx](http://www.cottoncra.org.au/content/Industry/Publications/Fibre_Quality/FIBREpak.aspx)

<sup>1</sup>Here fibre elongation refers specifically to the elongation of a fibre in length during its growth. In terms of fibre quality, fibre elongation also refers to the elongation in a fibre before it breaks in a strength test.

## BE AWARE OF

- Australia needs to maintain its reputation as a supplier of high quality cotton.
- The key management considerations for optimising fibre quality are variety selection and avoiding crop stress. So good water and fertiliser management is critical.
- FIBREpak contains more detailed information on improving fibre quality.
- For further support in crop management for improved fibre quality refer to the Fibre Quality module in myBMP.

**TABLE 1.**  
Consequences of poor fibre quality

| Fibre Trait           | Trait Description                                                                                                                                                                               | Ideal Range                                                                                                                                                                          | Consequences of poor fibre quality – cotton price                                                      | Consequences of poor fibre quality – spinning                                                                                                                                                                                                                                                     |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Length                | Fibre length varies with variety. Length and length distribution are also affected by stress during fibre development, and mechanical processes at and after harvest.                           | UHML in excess of 1.125 inch or 36/32nds. For premium fibre 1.250 or 40/32nds.                                                                                                       | Premiums can be gained for long staple length. Significant price discounts below 33/32nds.             | Fibre length determines the settings of spinning machines. Longer fibres can be spun at higher processing speeds and allow for lower twist levels and increased yarn strength.                                                                                                                    |
| Short fibre content   | Short fibre content (SFC) is the proportion by weight of fibre shorter than 0.5 inch or 12.7mm.                                                                                                 | < 8%                                                                                                                                                                                 | No premiums or discounts apply.                                                                        | The presence of short fibre in cotton causes increases in processing waste, fly generation and uneven and weaker yarns.                                                                                                                                                                           |
| Uniformity            | Length uniformity or uniformity index (UI), is the ratio between the mean length and the UHML expressed as a percentage.                                                                        | > 80%                                                                                                                                                                                | Small price discounts at values less than 78. No premiums apply.                                       | Variations in length can lead to an increase in waste, deterioration in processing performance and yarn quality.                                                                                                                                                                                  |
| Micronaire            | Micronaire is a combination of fibre linear density and fibre maturity. The test measures the resistance offered by a weighed plug of fibres in a chamber of fixed volume to a metered airflow. | Micronaire values between 3.8 and 4.5 are desirable. Maturity ratio > 0.85 and linear density < 220 mtex<br>Premium range is considered to be 3.8 to 4.2. (linear density < 180 mtex | Significant price discounts below 3.5 and above 5.0.                                                   | Linear density determines the number of fibres needed in a yarn cross-section, and hence the yarn count that can be spun. Cotton with a low micronaire may have immature fibre. High micronaire is considered coarse (high linear density) and provides fewer fibres in cross section.            |
| Strength              | The strength of cotton fibres is usually defined as the breaking force required for a bundle of fibres of a given weight and fineness.                                                          | > 29 grams/tex. For premium fibre > 34 grams/tex.                                                                                                                                    | Small premiums for values above 29 g/tex. Discounts appear for values below 27 g/tex.                  | The ability of cotton to withstand tensile force is fundamentally important in spinning. Yarn and fabric strength correlates with fibre strength.                                                                                                                                                 |
| Grade                 | Grade describes the colour and 'preparation' of cotton. Under this system colour has traditionally been related to physical cotton standards although it is now measured with a colorimeter.    | > MID 31                                                                                                                                                                             | Small premiums for good grades. Significant discounts for poor grades.                                 | Aside from cases of severe staining the colour of cotton and the level of 'preparation' have no direct bearing on processing ability. Significant differences in colour can lead to dyeing problems.                                                                                              |
| Trash/dust            | Trash refers to plant parts incorporated during harvests, which are then broken down into smaller pieces during ginning.                                                                        | Low trash levels of < 5%                                                                                                                                                             | High levels of trash and the occurrence of grass and bark incur large price discounts.                 | Whilst large trash particles are easily removed in the spinning mill too much trash results in increased waste. High dust levels affect open end spinning efficiency and product quality. Bark and grass are difficult to separate from cotton fibre in the mill because of their fibrous nature. |
| Stickiness            | Contamination of cotton from the exudates of the silverleaf whitefly and the cotton aphid.                                                                                                      | Low/none                                                                                                                                                                             | High levels of contamination incur significant price discounts and can lead to rejection by the buyer. | Sugar contamination leads to the build-up of sticky residues on textile machinery, which affects yarn evenness and results in process stoppages.                                                                                                                                                  |
| Seed – coat fragments | In dry crop conditions seed-coat fragments may contribute to the formation of a (seed-coat) nep.                                                                                                | Low/none                                                                                                                                                                             | Moderate price discounts.                                                                              | Seed-coat fragments do not absorb dye and appear as 'flecks' on finished fabrics.                                                                                                                                                                                                                 |
| Neps                  | Neps are fibre entanglements that have a hard central knot. Harvesting and ginning affect the amount of nep.                                                                                    | < 250 neps/gram. For premium fibre < 200                                                                                                                                             | Moderate price discounts.                                                                              | Neps typically absorb less dye and reflect light differently and appear as 'flecks' on finished fabrics.                                                                                                                                                                                          |
| Contamination         | Contamination of cotton by foreign materials such as woven plastic, plastic film, jute/hessian, leaves, feathers, paper, leather, sand, dust, rust, metal, grease and oil, rubber and tar.      | Low/none                                                                                                                                                                             | A reputation for contamination has a negative impact on sales and future exports.                      | Contamination can lead to the downgrading of yarn, fabric or garments to second quality or even the total rejection of an entire batch.                                                                                                                                                           |





**TABLE 2.**  
Key in-field management considerations for optimising fibre quality.

| Objectives                                                                                                  | Pre planting                                                                                            | Sowing to first flower                                                                                                                                                                 | First flower to open boll                                                                                                                                                                                                                                                                                           | Open boll to harvest                                                                                                                                                                                                                                        | Harvest to gin                                                                                                                                  |
|-------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| Realising the genetic potential for fibre length                                                            | Variety selection.<br>Strategic planning for irrigation availability.<br>Consider skip row for dryland. | Monitor soil moisture and schedule irrigation to optimise plant vegetative size.                                                                                                       | Monitor soil moisture schedule irrigation to optimise plant vegetative size and to avoid stress on developing fibres.                                                                                                                                                                                               |                                                                                                                                                                                                                                                             |                                                                                                                                                 |
| Maintaining fibre strength                                                                                  | Variety selection.                                                                                      |                                                                                                                                                                                        | Maintain healthy crop.                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                             |                                                                                                                                                 |
| Producing fibre with mid range micronaire to avoid fibres that have too high linear density or are immature | Variety selection.                                                                                      | Monitor soil moisture and schedule irrigation to optimise plant vegetative size. Sow at appropriate date for the region to avoid early crops in hot areas or late crops in cool areas. | Management of plant vegetative size, structure and balance with boll setting pattern. Uniform boll set is achieved by having the appropriate plant type for the variety, region and climate. Optimise agronomic management such as water, fertiliser and growth regulators. Adopt IPM to protect fruit, and leaves. | Timely harvest to avoid bad weather.<br>Use appropriate nitrogen fertiliser rates to match crop and fertiliser cut out.<br>Schedule last irrigation to leave soil at refill point at defoliation. Use appropriate timing, product and rate for defoliation. |                                                                                                                                                 |
| Reducing the incidence of neps                                                                              | Variety selection.                                                                                      |                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                             | Spindles and doffers maintained daily. Reduce spindle twist by not picking too wet.                                                             |
| Delivering clean white cotton with no stickiness                                                            | Weed management.                                                                                        | Weed management.                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                     | Fertiliser, irrigation and defoliant management as above. Refer to IPM guidelines for aphid and whitefly management.                                                                                                                                        | Picker setup – avoid pin trash and bark. Follow guidelines for module placement, construction, tarping and transport. Keep good module records. |
| Preventing contamination                                                                                    | Farm hygiene to avoid contamination during harvest later. Weed management.                              | Weed management.                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                             | Farm hygiene. Picking height. Hydraulics on pickers and builders checked and maintained.                                                        |

# Field selection & preparation

By **DALLAS KING, NILANTHA HULUGALLE, I&I NSW & TRACEY LEVEN, CRDC**



**Dallas King**

## Cotton soils

The soils on which cotton is grown in Australia are inherently fertile. They are dominated by cracking clays (Vertosols) which are naturally fertile, alkaline, with high clay content and high organic matter in soils that initially supported brigalow /belah associations. These soils were formed from fertile

alluvium and windblown dust under conditions of relatively low rainfall. (Hence, nutrients are not leached as in soils formed in more tropical areas). Other soil types on which cotton is grown include red-brown earths (in the Macquarie, Namoi and Gwydir valleys) and in many of the Queensland districts Solodic and Solodised-Solonetz form a part of the soil. These soils supported natural vegetation of woodland and grassland, prior to cotton cropping, the previous land use was grazing and dryland wheat production.

Cotton has poor tolerance of water logging. To allow adequate water entry, and to encourage root exploration by quickly re-establishing aeration after irrigation and rainfall, cotton soil needs to have good porosity for infiltration and internal drainage.

The alluvial soil types, black earths and the better structured grey and brown clays, with their extensive cracking – provide favourable conditions, for vigorous root growth. Soil types with dense, sodic subsoil's have

poor profile permeability and drainage, and hence limit root development.

Structural damage, due to excessive traffic or tillage at high moisture contents, may create large platy clods in any cotton soil. Such damage restricts permeability. While the root zone should be permeable, the deep subsoil should be almost impermeable; excessive deep drainage may cause water tables to rise. Irrigation management and crop rotation should aim to minimise the amount of water draining to the deep subsoil.

Crops are more likely to produce high yields when their roots are able to grow freely.

Root growth is retarded by the same factors that restrict water entry and seedling growth. Subsoil sodicity tends, however, to cause water logging by the process of excessive swelling rather than dispersion of clay particles.

For more information on Cotton Soils refer to **SOILpak**.

## Starting soil moisture

Large values of Plant Available Water Capacity (PAWC), which are found in some clay-rich alluvial soil types and deep black earths, allow a longer interval between furrow irrigations. Under dryland conditions, if the profile starts out full, large values of PAWC delay the onset of moisture stress in crops.

Compaction may also reduce the ability of a soil to allow water entry. An appropriate slope and field length, in combination with furrows and hills/beds, will ensure good surface drainage and reduce water logging. Land forming using laser grading usually is needed to provide the required slope across all parts of a field, particularly under irrigation.

Surface drainage and tail drains must be designed to minimise flooding during heavy rain, the consequences of which may be disastrous during the seedling stage. Furrow-edge compaction and water application rates need to be matched so that the root zone does not become waterlogged due to excessive water intake. Slopes that are too steep create erosion hazards.

Further information on PAWC can be found in the **Water Management** module in **myBMP** and in **WATERpak**.

## Soil variability

To allow efficient management of each crop area as a single unit, it is highly desirable that the soil of the area be fairly uniform. A complex distribution of soil types with differing tillage and irrigation requirements, for example, cannot be managed optimally.

In some cotton growing locations cracking clays are intimately associated with hard-setting soil types. The latter, with poor intake of water, require more frequent irrigation than the former, and often there are different fertiliser and herbicide requirements. Gilgai micro-relief, once levelled, can also provide a complex mosaic with former mound and depression sites giving differing crop performance which may persist for many years.

## BE AWARE OF

- Crop growth will be easier to manage in a field with a uniform soil type.
- Fix problems associated with land forming before planting cotton
- Favour fields that have most recently grown a crop other than cotton, where stubble has been retained and there is low risk of herbicide residues
- Consider alternative irrigation systems i.e. would lateral moves or pivots be more appropriate on lighter soils than flood irrigation.
- Consider suitable run lengths not just for cotton but possible rotation crops.





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## Soil surveys

Money spent on a soil survey before development usually is repaid several times over because of the potential management problems that it highlights. Soil survey information provides a benchmark that can be used to check progress with soil quality management as the cotton farming project proceeds.

When planning a new cotton development, each management unit should have soil condition and slope as uniform as possible. To achieve this aim, the soil should be mapped before any irrigation design work is carried out. In fields already developed for irrigation, variability problems may be so severe that the field must be redeveloped. Again, soil surveys should be made before redesigning.

When soil properties within a field are variable, it usually is impossible to deliver the required inputs to all sub-sections simultaneously when flood irrigation is used. Some parts of variable fields, therefore, will have lint yields that are lower than the field's potential, and product quality for the whole field will not be uniform.

In practice, it is unlikely to ever be economically feasible to completely remove across-field soil variability. However, if good quality soil survey information is available, the variation within each management unit can be minimised in a cost-effective fashion.

**Further information on mapping slopes and soil types across the farm can be found in the Natural Assets module in *myBMP***



## Land forming

Land forming of cotton fields often creates soil problems that should be dealt with before cotton is grown.

Issues include exposure and spreading of unstable subsoil, compaction, creation of abrupt texture-contrast boundaries and excessive dust production. These problems should be overcome before planting the next cotton crop.

Other soil problems (such as sodicity) that may have been identified during the pre-development soil survey can also be dealt with.

Subsoil exposure usually is unavoidable because of the need to provide an even slope in irrigated fields. Even drip irrigated fields have to be land formed because of the need to quickly dispose of runoff water after heavy rain. At best, the exposed subsoil will have inadequate organic matter.

At worst, it will be sodic, depleted of mycorrhiza, have a high pH and perhaps be saline.

Where sodic subsoil is exposed, the scraped material also has poor physical properties. It may be spread thinly over low lying areas which previously had a favourable soil structure. Therefore it is desirable to stockpile the original topsoil, landform the subsoil, and then replace the topsoil.

If stockpiling and replacement of the topsoil is not possible, the exposed sodic soil will have to be reclaimed by the use of gypsum, and perhaps by the growth of a well-fertilised cereal crop (e.g. Barley). Zinc fertiliser may need to be added.

Due to the tight schedules of land forming contractors, it is difficult to reshape fields at exactly the correct soil water content, particularly when there is a mix of grey and red soil. Nevertheless, a well fertilised crop such as wheat should be grown just before land forming to maximise the chances of the soil being drier than the plastic limit (PL).

If, however, there is heavy rain before land forming and the contractors cannot be delayed, deep compaction may occur. In this situation, the soil needs to be carefully re-assessed. Create beds and/or hills using a listing rig, preferably with a guidance system that ensures very straight furrows. Dig inspection pits close to at least three of the pre-development assessment sites, and use the soil inspection and interpretation procedures.

**For more information on soil constraints refer to the Cotton Nutrition and Soil Health chapter and SOILpak.**

**Further information:**

**SOILpak** – <http://www.dpi.nsw.gov.au/agriculture/resources/soils/guides/SOILpak/cotton>

**myBMP** – [www.mybmp.com.au](http://www.mybmp.com.au)

**WATERpak** – <http://www.cottoncra.org.au/content/Industry/Publications/Water/WATERpak.aspx>



# Row configurations

By **DAVID KELLY, CSD**

Acknowledgements: Michael Bange (CSIRO) and the CSD Extension team



There are a range of different configurations being used by growers across the cotton industry in semi-irrigated situations. These include single skip, 1.5m & 2m (60 & 80 inch), double skip, super single and some non-uniform configurations. The positive and negative features of each configuration including the relative

water use efficiencies depend on the individual situation. What works best in one farming system may not in another due to differences in soil type, environment, cropping history, available equipment, water availability and other factors.

Growers deciding:

- Whether they would benefit from using skip row configurations; and,
- Which skip row configuration they would use... should consider the following points:

## The advantages and disadvantages of each configuration

Extensive research has shown that while skip row cotton does limit yield potential (Figure 2), the combination of reduced fibre length discounts and variable cost savings in growing skip row cotton often lead to a better risk/return proposition.

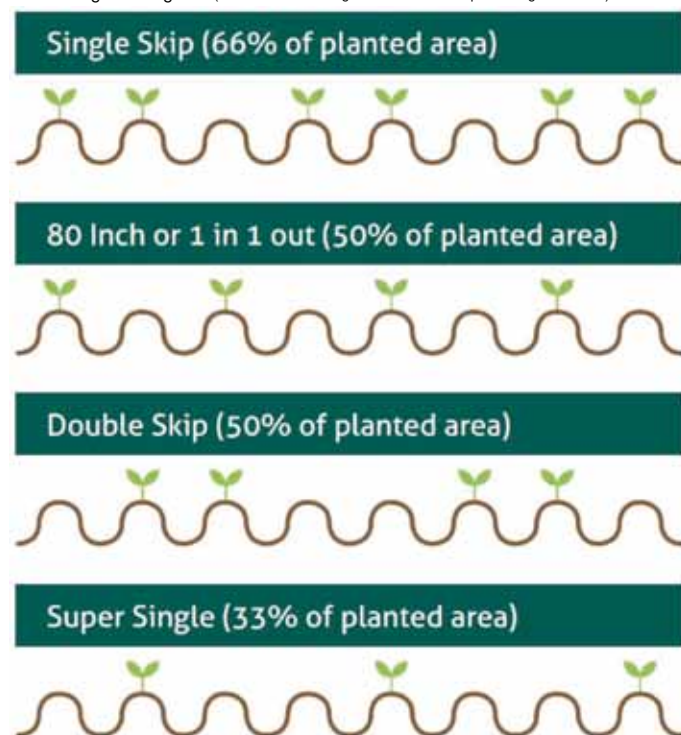
To use this graph, growers need to consider their yield potential, based on all the factors discussed later in this chapter.

## BE AWARE OF

- Different row configurations are being used by growers across the cotton industry in semi-irrigated situations – what works best in one farming system may not in another.
- Savings in variable costs of inputs are likely with wider row configurations.
- Wider row spacing configurations can be used to manage risk in dryland and semi-irrigated situations but will limit yield potential.
- Careful research is essential to assess the benefits of reduced costs and improved fibre quality when using different row configurations in water limited situations.

**FIGURE 1.**

Row configuration guide (Source: CSD Getting the most out of skip row irrigated cotton)

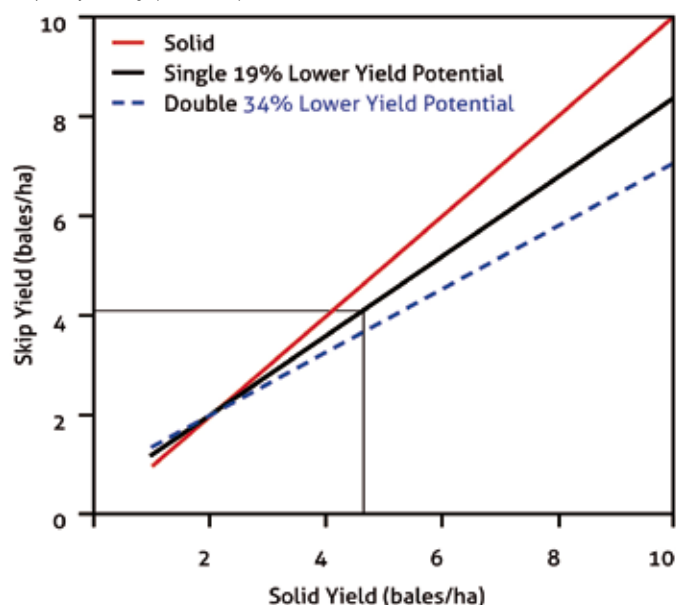


**Single skip** has the highest upside yield potential of these configurations averaging 19% decline from solid plant. It will however also use its moisture profile the quickest. Having a plant row 50cm one side and a one metre skip row to the other, this configuration will enjoy some benefits of mild early stress to limit vegetative growth. It is best suited to situations on heavier soil types with high Plant Available Water Capacity (PAWC) and more irrigation water availability.

While **one-in-one-out (or 2m or 80 inch)** cotton has not

**FIGURE 2.**

Comparison of average solid and skip row yields in dryland systems across several seasons and regions. Collated by Hearn (1999) and including some semi-irrigated treatments. Compiled by M. Bange (CSIRO 2006)



been included in these comparisons, grower experience and some trial work has shown its yield potential to be slightly higher than double skip but possibly more prone to fibre quality discounts because it does not have the advantage of mild early stress. A more uniform growth habit in 80 inch cotton can reduce lodging and allow better spray penetration and defoliation processes when compared to double skip.

Other advantages perceived by some double skip growers compared to 80 inch are:

- Gaps in stand are better compensated for.
- Growth management is easier due to mild early stress which can help limit vegetative growth.
- Double skip is easier for cultivation, especially if the 2m/80 inch row is in the middle of a 2m bed.
- Watering up – 2m/80 inch is more difficult to sub (ie, watering the sub-soil) to the centre of the bed.

**Double skip** has an average yield potential about 39% less than solid plant. Having a plant row 50cm one side and a 1.5m skip row to the other, this configuration provides the benefits of mild early stress to limit vegetative growth. Plants can be prone to lodging, especially vegetative branch fruit which takes advantage of the extra light available in the skip area. It is best suited to drier profiles and hotter environments.

Some growers have tried **super single** (one-in-two-out) in semi-irrigated situations. The widely spaced plant rows 2 metres apart means the yield potential and potential upside in a good season is severely limited. However, may be an option with a full soil moisture profile at planting and minimal irrigation water resources. This configuration allows growers to minimise growing costs as well as limit the likelihood of fibre quality discounts.

**Non-uniform configurations** have been tried in some circumstances but can lead to variability in maturity, and subsequent difficulties in management.

Skip row configurations function by increasing the volume of soil that plants have to explore, providing a bigger reservoir of available moisture and allowing the plants to hold on for longer during dry periods.

Skip row cotton provides an 'in between' option for increasing the area of cotton which can be grown, allowing some upside in production if conditions improve and far less downside in potential fibre quality discounts if the season deteriorates.

In some cases, inherent growing characteristics such as soil type and location may mean there is minimal advantage in adopting skip row practices (see Dryland Cotton chapter).

### Row configuration effects on cotton gross margin

The vigorous tap root of the cotton plant allows for wider exploration of the soil profile for moisture and nutrients, particularly when compared with fibrous root type crops. This characteristic has led to the use of wide row configurations that increase the total amount of soil moisture available to the plants. This extends the time

before in-crop rainfall is required and therefore makes the crop less reliant on in-crop rainfall particularly in the first 2–3 months of its life. Narrower row configurations such as single skip are more popular in higher rainfall eastern areas while the wider row configurations such as super single are used in the lower rainfall western areas.

The wide row spacings provide greater surety in yield and maintenance of base grade fibre quality. There is a strong relationship between row configuration and fibre quality, especially for fibre length. In row configuration trials, fibre quality improved with wider row configurations. Therefore the row configuration chosen in combination with the seasonal conditions experienced will have an influence on the likelihood of quality discounts being incurred on delivery of the cotton.

Savings in variable costs of inputs such as planting seed, insecticides, defoliant and the picking operation are likely with wider row configurations. Taking this into account, a lower yielding wider row configuration crop can at times give a better gross margin than a higher yielding crop on a closer configuration. In many ways growing skip row cotton really emphasises that gross margin is not just a function of the yield produced, but very much a combination of yield and costs associated with the row configuration chosen.

### Row configuration effects on variable costs

Cotton has a couple of big ticket items which make up the majority of the growing costs, these being picking and technology licence fees.

In wide row configurations, efficiencies in picking can be made through not trafficking every pass, with some contractors charging on a green hectare basis.

The technology licence fee of genetically engineered cottons can either be based on a green hectare rate or on an end point royalty scheme where the licence fee paid is related to the yield achieved. This not only works as a risk management tool but also in wider planting row configurations where the green hectare rate and yield potential is lower, it is also a cost management tool because the grower pays less.

#### Further information:

'Getting the most out of skip row irrigated cotton' – [www.csd.net.au](http://www.csd.net.au)



# Crop establishment

By **JAMES QUINN & DAVID KELLY, CSD EXTENSION TEAM**



James Quinn.



David Kelly.

## Target plant population

To optimise yield you should aim for an evenly spaced plant population from 5–13 plants per metre. You need to avoid gaps greater than 50cm. This has been verified by many years of experiments in Australian conditions.

There are some situations where growers should target the upper or lower end of this range.

Aim for the lower end of the range when:

- Planting dryland; and,
- Where you normally grow a larger plant size that can compensate well into spaces (e.g. in wetter, warmer climates and good soil types).

Aim for the higher end of the range when:

- Early crop maturing is essential (e.g. southern and eastern regions); and,
- Where you normally grow a smaller plant size that cannot compensate well into spaces (e.g. tight soils).

## BE AWARE OF

- The ideal planting time will vary between seasons and districts.
- Replant decisions should be based on good field information about the current population, its health and the cause of the stand loss.
- Remember that replanting needs to be completed within the planting windows for Bollgard II®.
- Crops planted outside the ideal planting window for your district will require special management
- A low and gappy plant stand can be very costly and difficult to manage.



**Aim to avoid gaps greater than 50cm – they have a large impact on yield.**

## Planting rate

The key considerations when determining how much seed you need is your desired plant stand, the seed size and seed quality for the variety you are growing, and how many seeds survive.

On average there are about 10,000 seeds/kg however there will be slight differences between varieties. The average seeds/kg for each variety is printed on the bag and also available on the CSD website.

**Seed quality:** All CSD seed has a minimum germination of 80% at the point of sale (most are a lot higher than this). Germination percentages for individual lots are available on the CSD website or contacting CSD's lab.

Seedling survival is rarely 100% so you can never bank on seeds/ha and plants/ha being the same.

- **Bed condition:** Uneven or cloddy beds can result in uneven seed depth and seed / moisture contact, resulting in a staggered germination and gaps.
- **Soil insects:** Particularly wireworm, can attack young seedlings. Seed treatment insecticides will control them but because the insect needs to feed on the plant before it dies, some plant loss can still occur.
- **Soil temperature:** Ideal soil temperatures for cotton establishment are 16°–28°C. Temperatures below this result in slow emergence and increased chance of soil diseases.
- **Seedling diseases:** Such as rhizoctonia, pythium and fusarium can kill young plants during and after emergence. This will be more prevalent at low temperatures, where there are high levels of crop residues and in fields with a history of disease.

Many of these factors are unavoidable and the best way to manage them is to increase the seeding rate.

There are more disadvantages in having a plant population that is too low than there are to having one too high.

## Planter setup

Ensure planter is well serviced and operational well before planting time because breakdowns in the field can rob you of time and allow surface soil moisture to further dry away.

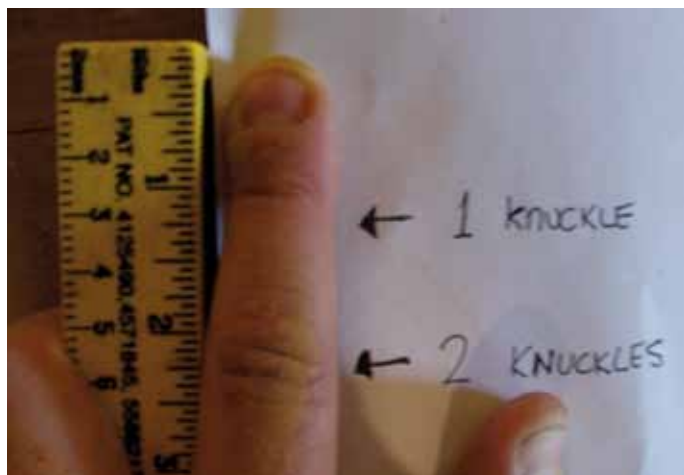
- Check that monitors are calibrated and working correctly.
- Chains and cogs need to be properly adjusted and lubricated.
- Spray lines and filters should be cleaned to stop blockages when planting herbicides or when in-furrow sprays are to be used.
- During the operation, regularly check seed depth and the condition of the soil around the seed. This is especially important when planting on rain moisture where you may get some variability.
- Keep a kit of spare parts (seed tubes, press wheels, scrapers, monitor cables, chains and nozzles) in the cabin to quickly allow for quick minor repairs.
- Planter seeding rates should be calibrated as well as granular insecticide rates if used.

## Planting depth

The depth you want your seed depends on the method you are intending to establish your crop. Many people like to use the 'knuckle' as a quick and easy measurement tool in the field (Figure 1)

**FIGURE 1.**

Checking the planting depth using your knuckles.



| Establishment Method                           | Ideal depth                        |
|------------------------------------------------|------------------------------------|
| Planting into moisture (rain or pre-irrigated) | 2 ½ and 4 ½cm<br>1 to 1 ½ knuckles |

### Be aware of

- If the beds are too wet at planting, you end up with a shiny, smeared slot which is very difficult for the young roots to penetrate. The result is often young seedlings dying from moisture stress, even if there is plenty of moisture down below.
- Check the consistency of the soil above the seed. If the pressure from the press wheels on the planter are set



**Particularly when planting on rain moisture, beware of uneven moisture throughout the bed which will cause variable crop development.**

too high, you can get a compacted zone above the seed and the young seedling will have a tough time getting out.

- Some dry soil above the seed slot is useful to prevent losing moisture from around the seed, however if there is too much, a rainfall event after planting will turn this dry soil into wet soil, and increase the depth for which the young seedling needs to push through.

| Establishment Method         | Ideal depth       |
|------------------------------|-------------------|
| Planting Dry and Watering Up | 2½cm<br>1 knuckle |

This method has advantages in hot climates, because it cools the soil and crop establishment is rapid. However, consider pre-irrigating when:

- There is a large seed bank of difficult to control weeds; and,
- The soil is very dry and temperatures are high.

Any shallower than 2½cm and the plant doesn't have



**Planting into moisture.**



the chance to scrape off the seed coat at germination and growth of that plant will be quite slow until that coat is thrown off.

- When planting dry, it's very important to be aware of the consistency of the seed bed. A poorly consolidated (or cloddy) hill can collapse when the water hits it and dropping the seed down to great depths, resulting in a poor or variable strike. This is especially important for crops coming out of sugarcane or corn.
- Sowing can be followed by an over-the-top application of Roundup Ready™ herbicide, targeting newly emerged weeds.

## Planting time

The ideal planting time will vary between seasons and districts.

**Start Time:** Planting should not occur until minimum soil temperatures at seed depth are maintained at 16°C at 10cm depth or more for three days and rising. Planting at temperatures below this will diminish root growth, reduce water and nutrient uptake and the plants are much more susceptible to seedling diseases and insects. History shows the incidence of replant has been much higher in situations where soil temperatures have been lower than ideal.

**End Time:** Agronomically, the end date is more important in short season areas where early crop maturity is essential. Shortening the length of the growing season will impact on yield, with 0.3 to 0.6 bales/ha for every week that the season is shortened. This is evident by the comparison of ideal planting times for northern, central and southern regions for irrigated cotton (see Figure 2). A sowing time response for dryland systems is presented in the chapter on dryland yield and risk at the start of this manual.

The adoption of Bollgard II® cotton has helped eliminate some of the desire for very early planting because:

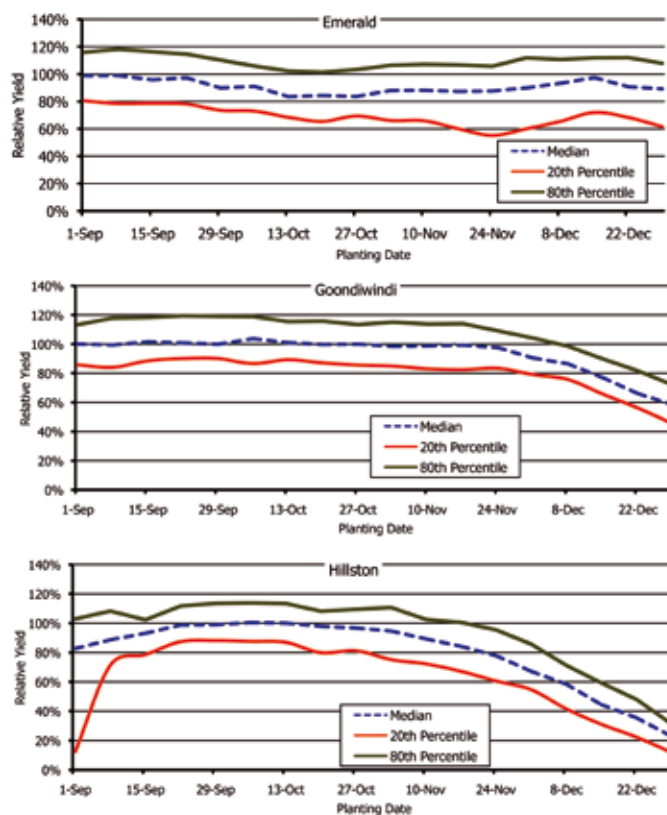
- These crops tend to retain more early fruit and hence a quicker time between planting and picking.
- The season-long Helicoverpa control offered by this product diminishes the risk of high late-season insect numbers and control costs associated with conventional cotton.

Where season length allows, planting slightly later has a lot of advantages:

- It will increase the likelihood of warm temperatures at planting, resulting in increased seedling survival and vigor.
- A crop established under warm conditions has the potential to produce bigger plants, hence greater leaf and stem area to sustain boll development later in the season.
- Later planting will delay the peak flowering period past the hot conditions often associated with late December/ early January period. This can reduce the likelihood of premature cut-out, higher micronaire, and can contribute to increased fibre length..

**FIGURE 2.**

Irrigated cotton yield potential by sowing date for Emerald, Goondiwindi and Hillston.



Data generated by CSIRO using the OZCOT model assuming soil Plant Available Waterholding Capacity (PAWC) of 200mm (Emerald and Goondiwindi) and 150mm (Hillston), Irrigation deficit of 70mm, Water allocation for the season of 8ML/ha.

Note: Planting 'slightly later' will mean different things in each region, depending on season length:

- In cooler areas in the south and east it may mean planting in mid October.
- In central regions it may mean mid to late October.
- In northern and western regions it may mean mid October to early November.

Other factors that need to be considered in determining planting date:

- Late maturing crops may be more susceptible to pests such as silverleaf whitefly and aphids.
- Availability of harvest machinery if a crop is much later than others in the district.

In all cases, people growing Bollgard II® cotton need to plant within the planting window for their district. This information is available in the Bollgard II® Resistance Management Plan which can be found in the Cotton Pest Management Guide.

## Planting on rain moisture

Although this is what dryland growers do every year, many irrigators also aim to establish their crop on rain moisture to save water on pre-irrigation or watering up.

There are a number of factors that will improve the likelihood of success with planting into rain moisture and some cautionary points for those attempting it on irrigated country.



**Cereal stubble is important in the establishment of dryland crops – it improves moisture infiltration and protects the young seedlings from sandblasting.**

### Stubble

The presence of standing stubble will increase the chance of seedling survival in moisture planting situations dramatically because it increases the amount of infiltration and hence moisture available to the seedling, it reduces surface evaporation and it protects the young seedling from the elements.

### Bare fallows in irrigation country

This is a risky practice and often results in replants if conditions are not ideal. Fields tilled for irrigation are designed to shed water so you need to check whether moisture has infiltrated to any depth into the seed zone.

- In cloddy seedbeds the fine materials may be wet but the larger clods may be dry and may draw moisture away, drying the seed bed.
- Check across a field to see whether the rainfall has been uniform.
- When planting, check soil moisture levels in the seed zone regularly.
- In furrowed fields, rainfall will usually not fill the soil profile as well as irrigation so after emergence, soil moisture levels and the vigor of the young seedlings need to be monitored closely as an early first irrigation may be required.

## Do I need to replant?

The decision as to whether to replant or not is sometimes a straightforward decision, and other times not. The obvious question is “will I achieve a better result with the plants I’ve got or should I start again?”

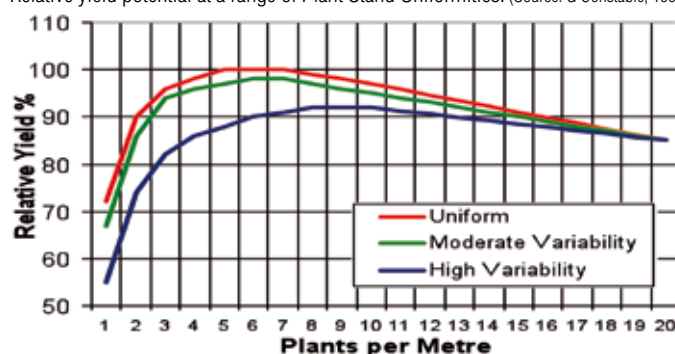
The decision needs to be made carefully, based on good field information on the current population, its health, the cause of the stand loss the implications of replanting and the implications of managing a low plant stand. Some factors to consider:

### Measure your plant stand

Figure 1 demonstrates the relative potential yield of plant stands that are variable or non-uniform compared with a uniform stand. A plant stand with high variability is one having 2 or more gaps greater than 50cm in length every 5 metres of row. The data also shows that 5–10 plants/m of row has the best yield potential; variable stands will reduce yield for all plant populations.

**FIGURE 3.**

Relative yield potential at a range of Plant Stand Uniformities. (Source: G Constable, 1997)



### Causes of the plant loss

Establishing the cause of the stand loss is important so you can determine whether further plants will die and also if you choose to replant, whether the crop will succumb to the same problem again. Often stand loss is due to a combination of factors.

- **Insect Damage:** If insects such as wireworm are the cause of plant loss assess whether they are still present and continuing to kill plants. If you replant, use an in-furrow insecticide or a robust seed treatment at a higher planting rate.
- **Diseases:** If seedling disease is the cause of the stand loss consider whether plants are still dying and likely to reduce the plant stand further. Generally higher soil temperatures will reduce their incidence when replanting.
- **Soil Characteristics:** In sodic or hard setting soils, seedlings may be slow in emerging or get stuck under a crust. Sometimes the mechanical breaking of this crust to allow the young seedlings through, maybe more effective than replanting.
- **Herbicide Damage:** If planting herbicides washing into the root zone has injured or killed young seedlings, consider whether this will reduce the population further and whether it will impact on replanted plants.



- **Fertiliser Burn:** If ammonia burn has killed young seedlings, the replant should be off-set from the original problem so it does not reoccur.
- **Hail or Sandblasting Damage:** Try and determine whether the surviving seedlings will regrow.

### The implications of replant

- **Replanting Date:** Relative yields decline by late October in warmer growing regions and earlier in cooler regions (Figure 2). This reduction in yield potential should be factored into replant decisions, as a low population or gappy stand may have a greater yield potential than one which could be replanted.
- **Soil Moisture Status:** In seasons where irrigation water is such a limiting factor, the soil moisture status is a critical factor in determining whether or not a replant is justified.
  - Is flushing or rainfall going to get dry seeds up?
  - What implication does this have to the water budget for the rest of the planted acreage?
- **Dry Seeds:** Seeds can survive in soil for a long time. Consider if a stand will be improved if rainfall or irrigation germinates these dry seeds.
- **Variety Selection:** If the replant means you are planting late in the window, choose a variety which has performed well in late planted scenarios in your area. These are typically the more determinant variety with inherently longer, stronger and mature fibre as cooler conditions at the end of the season can negatively impact on fibre quality. Check variety guides for suitable varieties.

Remember, any replanting needs to be completed within the planting windows for Bollgard II®.

### The implications of not replanting

Sometimes sticking with the plant stand you have is a better option than replanting. There are some considerations of managing a low plant population.

- **Lower Yield Potential:** If possible, prioritise resources to fields with better plant populations and higher yield potentials. This is particularly relevant in limited water situations.
- **Weed Populations:** Low plant populations with gaps may encourage weed problems later in the season due to lack of competition. A plan for their management should be devised early.

Further information  
CSD – [www.csd.net.au](http://www.csd.net.au)



Avoid planting into fields with established weeds – they will draw moisture out of the profile so it's not available to the young seedlings.



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# Crop growth stages

By **JAMES QUINN & DAVID KELLY, CSD**  
EXTENSION TEAM



**James Quinn.**



**David Kelly.**

## Day degrees

The cotton plant is quite predictable and well understood in the way in which it grows

and responds to the environmental or management factors that are applied to it. A crop can therefore be monitored and influenced to achieve desirable outcomes.

Temperature has a major influence on the rate of development and growth of the cotton plant, especially early in the season. This relationship between temperature and growth rate is described as Day Degrees.

The relationship between plant growth and temperature for Australian conditions is described by the following equation.

$$\text{Day Degrees} = \frac{(\text{Maximum Temp} - 12) + (\text{Minimum Temp} - 12)}{2}$$

Example:

$$\text{Maximum temp} = 30^{\circ}\text{C}, \text{ Minimum Temp} = 20^{\circ}\text{C} \quad \frac{(30-12) + (20-12)}{2} = 13 \text{ Day Degrees}$$

When minimum temperatures are less than 12°C, day degrees are calculated as:

$$\text{Day Degrees} = \frac{(\text{Maximum Temp} - 12)}{2}$$

## BE AWARE OF

- Temperature has a major influence on the rate of development and growth of the cotton plant.
- Seedling establishment is best if minimum soil temperatures in the seed zone are at least 16°C for 3 days at sunrise.
- The aim is to keep in balance the reproductive and vegetative growth to produce the highest amount of cotton at harvest.
- The 'Crop Development Tool' on the Cotton CRC website can assist growers and consultants in monitoring their crop development.
- Not regularly monitoring crops can make management difficult and less effective.

The average day degrees for vegetative and reproductive growth in Australia are shown in Table 1.

**TABLE 1.**

Average day degrees for vegetative and reproductive growth of cotton in Australia.

| Phase                   | Day Degrees |
|-------------------------|-------------|
| Sowing to Emergence     | 80          |
| Growth of One Node      | 40          |
| Initiation of Square    | 220         |
| Sowing to first Square  | 505         |
| Square to Flower        | 270         |
| Flower to max boll size | 310         |
| Max boll size to mature | 365         |
| Mature to fully open    | 75          |
| Flower to open boll     | 750         |

In warmer climates, Day Degrees may over-estimate the development of the crop. As in the cooler climates where cool temperatures (<11°C) delay the development of the crop so too can excessively hot temperatures, (>35°C).

Growers and consultants can track their crop progress and compare with historical averages (generated from climate data) using the day degree calculator on the CRC website. <http://CottASSIST.cottoncrc.org.au/DDC/DDCTool.aspx>

In very high temperatures as well as crop development being slowed so is crop growth. Very high temperature increase the use of plant uses resources and energy to transpire and respire in an effort to keep cool. In addition reduced leaf biomass and fruit shedding can be a result of high day and night time temperatures.

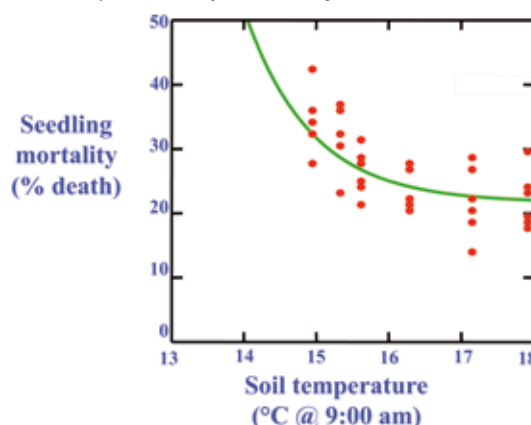
## Germination and emergence

As soon as a cotton seed touches moist soil, it will take in (or imbibe) moisture and begin to germinate.

Emergence is when the cotyledons break the soil surface and unfurl. The warmer the soil temperatures, the

**FIGURE 1.**

Impact of soil temperature on Seedling Mortality. Temperature is the average minimum soil temp. for the 7 days after sowing.





quicker this will happen. Seedling establishment is best if minimum soil temperatures in the seed zone are at least 16°C for 3 days at sunrise. At temperatures below this, seedlings are more susceptible to seedling diseases, black root rot and *Fusarium* species.

Studies conducted by Dr David Nehl (NSWDPI) have shown dramatic increases in seedling mortality once minimum soil temperatures fall below 15°C in the week post planting (see Figure 1).

## The growth of a cotton plant

The cotton plant has an indeterminate growth habit, which means it puts its fruit on over a period of time not all at once. The rate of development can be mapped through the life of the crop and it follows a specific pattern. This growth is driven mainly by temperature and therefore we use the day degrees calculation to monitor and predict crop development.

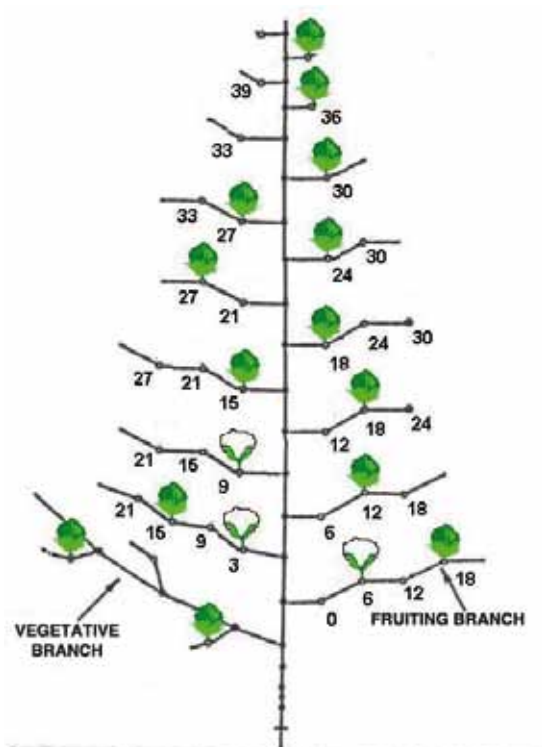
There are two aspects of the growth of a cotton plant, vegetative and reproductive growth. Due to the indeterminate nature of the cotton plant the vegetative and reproductive growth occur in parallel. The aim is to keep in balance the reproductive and vegetative growth to produce the highest amount of cotton at harvest.

The following diagram shows the average time of development of the fruiting sites for cotton; for example on this plant the fruit at the very top of the plant will start (and finish) developing about 27 days after the first fruit at the bottom of the plant.

In the development of a cotton boll, the fruiting structure goes through 3 distinct phases as shown below.

### FIGURE 2.

Rate of development of fruiting sites on a cotton plant, adapted from Oosterhuis 1990



### In the development of a cotton boll, the fruiting structure goes through 3 distinct phases as shown below



#### Square.

The flower 'bud'.



#### Flower.

The blooming of the cotton flower; it is a white flower which turns pink after one day, post fertilisation and withers and falls off.



#### Boll.

After the flower petals fall off, what remains is the fertilised boll, or fruit of the cotton plant. This boll grows in size developing the seed and fibre in side. At maturity the boll walls crack and the lint dries out into the ball of cotton.

## Squaring

First Square is the beginning of the reproductive phase of growth of the cotton plant. Normally this occurs between the 6th and 10th node depending on seasonal conditions and variety. Initiation of this first square normally occurs at the time the true leaf on node 4–5 is unfurled. As the plant grows additional fruiting structures will emerge at about one every three days for first position fruit which are those which are closest to the main stem. The rate of appearance of squares will however, slow as the crop starts to develop a fruit load.

## Flowering

The cotton flower is white, with five petal flowers and normally opens first thing in the morning. The cotton plant is usually self pollinating and this occurs very shortly after the flower opens. Once fertilised the flower turns reddish purple and then desiccates as the boll begins to develop.

## Boll filling

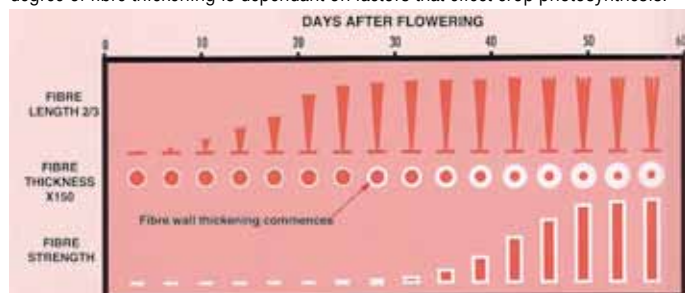
After fertilisation, the boll or fruit begins to develop. The boll is divided into segments of capsules called locks. These contain the seed and lint. Typically the boll has 3 to 5 locks which contain 6–9 seeds.

The boll increases in size rapidly after fertilisation of the flower and reaches its full size about 20–25 days later. Fibre length is determined during this period, and the maturity or micronaire of the fibre occurs in the second half of the bolls development which in total will take about 50 days (Figure 3).

Once mature, the boll will split and the cotton seed and fibre will expand out of the capsule to form a white fluffy bundle of seed and lint

**FIGURE 3.**

The fibre develops in length for about 18-24 days after flowering (temperature dependant). Shortly before this elongation stops, thickening of the fibre wall begins, and it continues for about 40 days or so until shortly before the boll opens. The degree of fibre thickening is dependant on factors that effect crop photosynthesis.



### Cut out

As the cotton plant continues to develop bolls, the demand for carbohydrates that are produced in the leaves increases. Eventually the demand by the bolls exceeds supply, resulting in the production of new fruiting nodes ceasing and the shedding of excess bolls, less than 14 days old. This point is known as 'cut-out'. An approximation of the timing of cutout is when a crop has reached on average 4 nodes above white flower (NAWF). About this time the earlier set boll will start to open and measurements nodes above cracked boll should be used to determine the timing of the last irrigation and defoliation

## Monitoring growth rate and development

The cotton plant has a structured growth habit which is driven by temperature or day degrees, and therefore its development can be tracked throughout the season. The following outlines some measurements which may assist in the management of the crop for maximum potential.

### Measuring NAWF (Nodes Above White Flower)

The NAWF measure is a used to assess health and the time to cut out of the crop (4 NAWF) and it is used to signal the last effective square. At first flower in a healthy crop the NAWF should be above 7. An aim for cotton growers in trying to maximise yield potential is to try to keep the NAWF above 4.5 for as long as possible. Once the NAWF falls below 4 cut-out is reached.

### Measuring NACB (Nodes Above Cracked Boll)

The NACB measure is used to determine the time required before the crop reaches maturity. When the crop reaches the '4 NACB' stage, the uppermost boll will have reached 'effective' maturity, when fibre development on all bolls is complete and defoliation can occur without risk of reducing yield and quality (refer to figure 4).

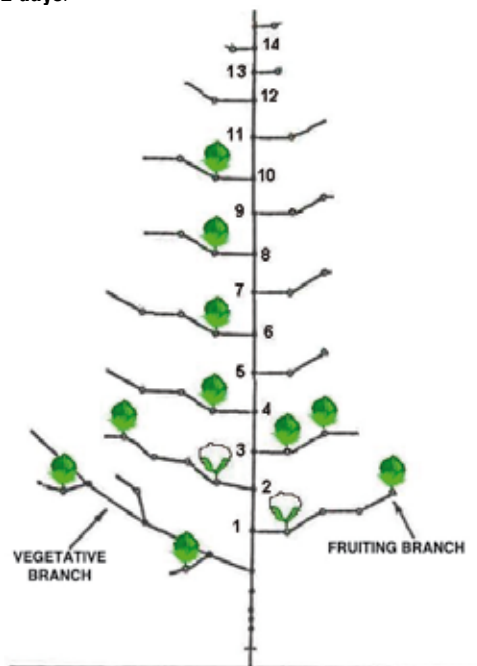
On average, bolls will sequentially open at a rate of a **node every three days**. This will depend on a number of factors, particularly climatic conditions.

### When NACB doesn't work

In situations such as heavily tipped conventional crops,

**FIGURE 4.**

Fruiting Branches (FB) are numbered 1-14 in this example Cracked Boll is FB2, Last Harvestable Boll is FB 10 and Nodes 9, 7 and 5 have no fruit. **NACB** on this plant is **8**. Assuming the bolls open at **3 days per node**, the crop will reach **4 NACB in 12 days**.



thin stands with plants with high numbers of vegetative branches and also in crops which have restarted after late season rainfall, fruit set will not be uniform in these crops; the NACB technique does not give an accurate indication of maturity. The only reliable method is to cut bolls (See figure 5).

Bolls have reached maturity when they are difficult to cut with a sharp knife, the seed embryo is developed and the seed coat has turned brown and black.

As with all determinations of crop maturity it is critical that only bolls which will be harvested are monitored.

### Measuring Vegetative Growth Rate (VGR)

Measuring the VGR is a method of assessing the growth rate of the crop. It is a simple measurement which compares the change in the height to node ratio over time. This method developed in Australia for Australian conditions is the most accurate way in which to assess this ratio.

$$VGR = \frac{(\text{This weeks height} - \text{last weeks height})}{(\text{This weeks nodes} - \text{last weeks nodes})}$$

**FIGURE 5.**

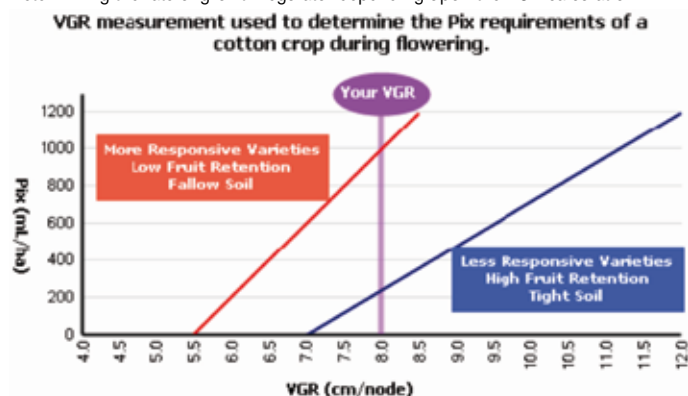
Appearance of youngest bolls when cut, showing corresponding NACB.





**FIGURE 6.**

Determining the rate of growth regulator depending upon the VGR calculation.



### The decision to apply a growth regulator

It is important to keep the reproductive and vegetative growth in balance. As the crop early in its life cycle will be developing in warm and moist conditions, the tendency in these conditions is for the vegetative growth may over run the reproductive growth. Applications of Mepiquat chloride may be required to limit the vegetative growth, especially during the critical squaring and early flowering stages of development. Figure 6 shows the rate of growth regulator to use depending upon the VGR calculation.

### Factors which will influence the decision include

- **Fruit Status:** High fruit retention can limit vegetative growth as the plant needs to allocate resources to filling young bolls, and hence less is available to produce vegetative growth. The opposite applies for crops with low retention.
- **Moisture Status:** Growth regulator applications combined with moisture stress can result in yield reductions. Before applying a growth regulator, consider if there is any chance that the crop may get 'hot' or water logged within the days or week after application.
- **Field History:** Some fields (or parts of fields) are prone to rank growth or alternatively grow poorly. This will influence sampling for VGR and may lead to differential application rates. Often fallow fields may be more prone to excessive growth than back-to-back fields.
- **Variety:** A number of trials have been conducted to look at the response of different CSD varieties to Pix® applications. The trials have shown that varieties vary in yield responsiveness to applications of Pix®, often independent of height responsiveness.

The 'Crop Development Tool' on the Cotton CRC website can assist growers and consultants in monitoring their crop development, and help provide information on managing the balance of fruit and vegetative crop growth to optimise yield. <http://CottASSIST.cottoncrc.org.au/CDT/>

### Measuring fruit retention

To get an indication of the fruit demand of a crop a quick method is to look at first position fruit retention.

This measurement when carried out a number of times throughout the season will give an assessment of the yield potential the crop has.

There are two main ways to measure the fruit retention:

#### 1. 1st Position Fruit retention

Crop yield and maturity is not affected if the 1st position fruit retention is maintained at around 60% at the time of first flower. After flowering, 1st position fruit retention is of limited value.

1. Select a plant and count the number of fruiting branches. Count as high as the last fully expanded leaf.
2. Count the number of first position square and bolls. First position fruit are those closest to the main stem. If the fruit is missing, you can see a small oval shaped scar left on the branch.
3. Conduct this fruit retention measurement on at least 30 plants per field at a number of points.
4. To calculate the 1st position retention  

$$= \frac{\text{1st position squares} \times 100}{\text{Fruiting Branches}}$$

When first position fruit retention falls below 50%, it should signal some caution, but certainly not panic. Many people have experienced very low fruit retention and are still able to achieve good yields.

#### 2. Top 5 retention

This is a more rapid way of calculating fruit retention and may be more indicative of recent fruit loss.

1. Select a plant and count the number of squares in the 5 nodes below (and including) the node where there is a fully unfurled leaf.
2. Conduct this fruit retention measurement on at least 30 plants per field at a number of different points in the field.
3. To calculate the top 5 retention  

$$= \frac{\text{1st pos. squares on the top 5 fruiting branches} \times 100}{5}$$

#### Further information:

Crop Development Tool – [www.CottASSIST.cottoncrc.org.au](http://www.CottASSIST.cottoncrc.org.au)

CSD – [www.csd.net.au](http://www.csd.net.au)

# Varietal selections

By **ROBERT EVELEIGH, CSD**



There are a large number of varieties that can be selected and grown. Varieties are generally chosen based on yield, quality and disease resistance characteristics. However other traits such as determinacy, leaf shape and season length may also be important. The full range of cotton varieties available are outlined on

the CSD web page ([www.csd.net.au](http://www.csd.net.au)).

## Yield

In irrigated production systems yield is the primary selection characteristic. Some varieties are widely adapted and can perform in a range of environments. Varieties in the Sicot 71 family have demonstrated exceptional yield performance in a wide range of environments. Other varieties such as the Sicot 43 family only perform well in specific short season environments.

Dryland production systems require varieties that yield well in water limited situations. The best dryland varieties are generally very indeterminant and have robust fibre characteristics.

The relative performance of cotton varieties can be compared online at [www.csd.net.au](http://www.csd.net.au) using the variety comparison tool and the latest variety guide should be consulted to assist in selection.

The final yield of any variety is the product of its yield potential limited by the environment. It is worth your time to select the best performing variety for your farm. In fact different fields on your farm may require different varieties to achieve the highest yields. Varieties can be selected on past performance but most new varieties will have to be selected on their results in variety trials. Historically cotton growers change varieties rapidly to grow the higher yielding replacements. Cotton varieties bred in Australia have demonstrated a 1.8% increase in average yield per year, so newly released varieties may be the best choice for your farm

## BE AWARE OF

- The final yield of any variety is the product of its yield potential limited by the environment.



**CSIRO breeder Greg Constable inspects CSIRO variety trials.**

## Quality

Australia cotton is regarded as some of the best in the world. Apart from lack of contamination the intrinsic fibre characteristics have been improved by breeding. Fibre length has been increased significantly in the last few years. Breeding has also increased fibre strength and has also reduced micronaire values down to the premium range. Some varieties such as Sicala 340BRF have exceptional quality and may achieve premiums. However Pima varieties such as Sipima 280 have the best quality and generally command a higher price for lint. There is an inverse relationship between yield and most fibre quality traits, but through careful selection breeders have been able to achieve high yielding varieties with good fibre quality.

Some fibre quality traits are more important in particular environments. In the hotter regions selecting varieties with lower relative micronaire may assist in minimising discounts and achieving premiums. In dryland situations selecting varieties with the best fibre length will reduce the chance of length discounts. Variety selection can also impact on grades. Okra leafed varieties sometimes achieve slightly lower grades than normal leaf varieties due to the leaves 'catching' on the plant and contaminating the lint. Careful defoliation and ginning will limit any grade loss.

For more information refer to the **Managing for Fibre Quality** chapter or to **FIBREpak**.



## Disease

Breeding has provided the main method of managing our major diseases such as verticillium and fusarium wilt. The industry has developed a ranking system (F rank for fusarium and V rank for verticillium) to allow growers to compare the disease resistance of varieties. The ranking systems use a number system to compare new varieties to a standard. A rank of 200 would indicate the variety is immune to fusarium wilt and verticillium. The best commercial varieties available currently have an F rank of about 130 and a V rank of around 110. Breeding aims to improve the disease resistance over time and new varieties generally have improved F rank.

In fields with significant disease pressure, yields can be maximised by selecting varieties with the highest disease resistance. In the case of fusarium and verticillium selecting the most resistant varieties can reduce spore numbers in the soil, thereby reducing its impact on subsequent crops.

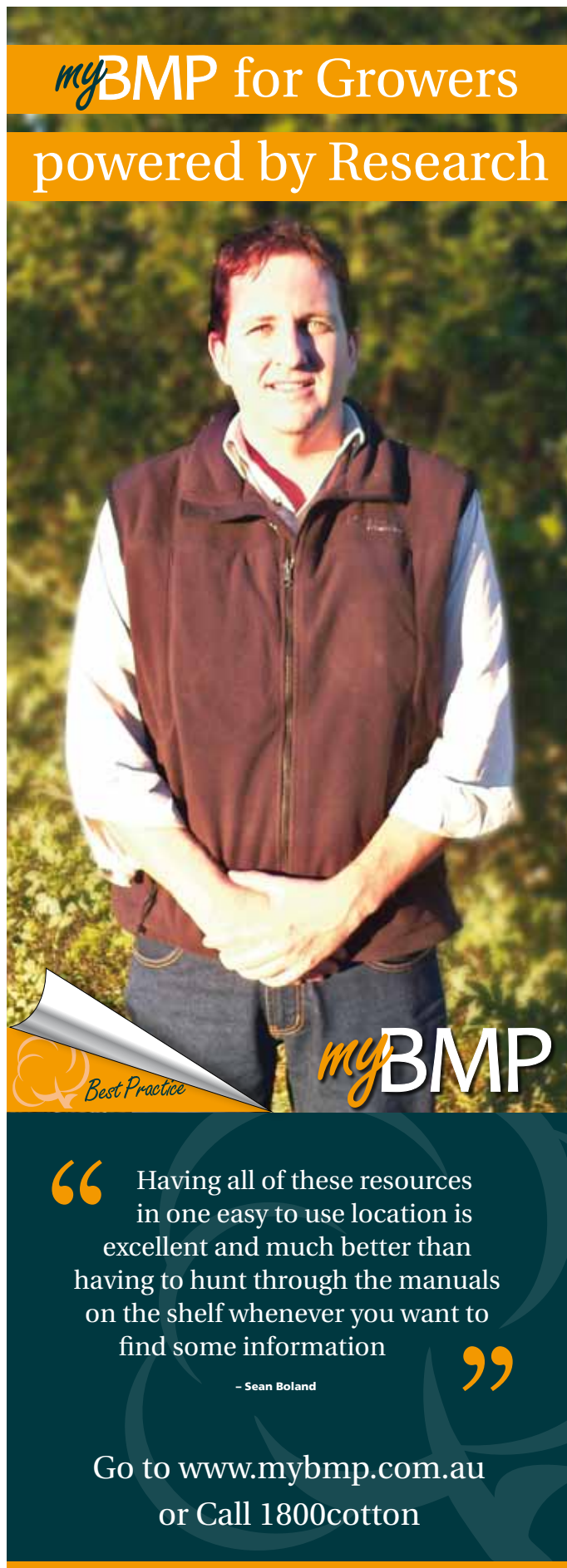
The latest disease rankings are available in the CSD Variety Guide and online at [www.csd.net.au](http://www.csd.net.au)

For more information refer to the Disease Management chapter.

## Okra leaf shape

The 'okra' leaf shape has been used in some Australian varieties since the early 1980s. It is a useful trait that has demonstrated some resistance to helicoverpa, mites and more recently whitefly. Varieties with 'okra' leaves have also been shown to be more water use efficient. However the trait requires careful breeding to achieve equivalent yields to the best normal leafed varieties.

Further information:  
CSD – [www.csd.net.au](http://www.csd.net.au)



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# Biotechnology traits

By **STEVE AINSWORTH, CSD**



The introduction and adoption of biotechnology traits has delivered significant benefits for Australian cotton growers and cotton production systems. Following the introduction of the first biotechnology trait (INGARD® cotton in 1996), biotechnology has today become a very important

feature of cotton production and a key component in cotton breeding programs. In 2010, approximately 98% of the cotton planted in Australia contained at least one biotech trait which underlines the importance of the technology to Australian cotton growers.

Biotechnology has delivered real benefits to cotton growers and has significantly reduced some of the production risks associated with the crop. This has directly enabled growers to focus on key management strategies to drive yield and fibre quality outcomes. The technology has also allowed growers in non-traditional growing areas to explore cotton as a mainstream cropping option and adapt their farming system (irrigated or dryland) to benefit from cotton as part of their rotation.

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.

**Bollgard II®** technology provides control and aids the management of *Helicoverpa* species in cotton. It expresses two specific proteins isolated from *Bacillus thuringiensis* (Bt) which are efficacious against *Helicoverpa armigera* and *Helicoverpa punctigera*. One of the key benefits of Bollgard II has been the significant reduction in insecticide use which has allowed for an increased adoption of IPM principles as well as providing growers with a consistent platform to manage insect control costs.

**Roundup Ready Flex™** technology confers full season tolerance to glyphosate herbicides. The ability to use Roundup Ready® herbicide in crop to control a wide range of weeds in crop allows growers to design weed control programs that can target individual fields and specific weed problems. The technology has reduced the reliance on pre-emergent herbicides and has allowed growers to more effectively use minimum tillage techniques and reduce manual weed chipping costs.

**Liberty Link®** cotton confers tolerance to Liberty® (glufosinate ammonium) herbicide which is registered to control a range of broad leaf and grass weeds in crop. This technology utilises the herbicide glufosinate which has particular strengths including the ability to control hard to kill weeds including weeds like peach-vine which are not well controlled by glyphosate. Liberty herbicide also provides useful control of glyphosate tolerant cotton volunteers.

## The future

Biotechnology is a rapidly developing field of science and cotton is a global core crop benefiting from this global investment. There is a dynamic horizon of novel and emerging technologies in various stages of development which continue to provide opportunities for the cotton industry to address production and environmental challenges. Whilst today's trait portfolio is strictly confined to insect (lepidopteran) and herbicide tolerance, a raft of new technologies is close at hand with potential solutions likely for abiotic stresses (moisture & disease tolerance), new classes of herbicide tolerance, broader insect control platforms and nitrogen use efficiency technology to name but a few.

## Accessing biotechnology traits

The access to the various traits is governed by the major technology companies who develop and commercialise the technology via an annual license called a 'Technology User Agreement' (TUA). The TUA forms the basis of the relationship between the grower and the technology company. Its primary purpose is to clearly define the terms and conditions associated with use of the technology in a particular cotton season. It covers a broad array of matters and includes the prices, payment and risk management options for the technology. It also includes stewardship requirements particular to a technology.

In practicality, the actual licensing process is managed by Technology Service Providers (TSPs) on behalf of the technology companies. TSPs are primarily well known local and national retailers of crop protection products and cotton planting seed. Growers should direct initial enquiries about accessing biotechnology to their local TSPs.

A list of current TSP's can be located at:  
[www.monsanto.com.au/products/cotton/](http://www.monsanto.com.au/products/cotton/)  
[www.bayercropscience.com.au/](http://www.bayercropscience.com.au/)

## Stewardship

All cotton biotechnology traits commercialised in Australia are supported by an appropriate stewardship program which forms part of the annual Technology User Agreement (TUA) between technology owners and growers. The stewardship programs are a product of collaboration between the cotton industry and the developers of the technologies with an aim of supporting their long term sustainable use. This is





of natural resistance to technology (for example to prevent the development of populations of target insects that are resistant to the Bt proteins in Bollgard II® cotton, or to prevent the development of annual ryegrass populations that are resistant to glyphosate, the active ingredient in Roundup branded agricultural herbicides). These plans are important to ensure that Australian farmers continue to reap the benefits of GM technologies for many years.

Specific trait stewardship information can be found at the following websites:

[www.monsanto.com.au/products/cotton/](http://www.monsanto.com.au/products/cotton/)

[www.bayercropscience.com.au/](http://www.bayercropscience.com.au/)

INGARD™, Bollgard II® and Roundup Ready Flex® are trademarks of Monsanto Technology LLC used under license by Monsanto Australia Limited  
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important to ensure the traits continue to provide value to growers and more importantly provide a basis for the introduction of new novel traits.

Stewardship programs are reviewed periodically to ensure that they are delivering against this goal and where necessary, changes may be implemented to ensure that any risks to the sustainability of a particular technology can be managed.

A key part of the stewardship program is the development of management plans that clearly set out the requirements for on farm management of crops containing GM technology. These plans are developed in consultation with industry groups and key researchers. They include:

- **Crop Management Plans** that cover all aspects of the crop from seed receipt to grain delivery.
- **Resistance Management Plans** that specifically aim to prevent the development



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# Crop rotations

By **DALLAS KING**



A vital component of any farming system is the inclusion of a rotational phase. Although the majority of cotton valleys have experienced reduced production due to drought there is an opportunity once production returns to more “normal” levels to consider the benefits of rotational crops and not just drought induced fallows.

Rotations are important to plant disease because they affect the survival and reproduction of plant pathogens and the biology and quality of soil. However disease is only one of several factors to consider when choosing a rotation sequence.

## BE AWARE OF

- Some rotation crops can be beneficial in managing cotton diseases.
- Rotation crops are important for Integrated Weed Management.
- The Crop Rotation Finder on the Cotton CRC web site can help with rotation crop decisions.

Rotation crops and fallows are also an important part of the Integrated Weed Management strategy, as well as being beneficial for managing diseases, insects, and soil problems. Rotation crops and fallows give cotton growers the opportunity to use a different range of herbicides, and to use strategic cultivation to manage specific problems.

One of the difficulties with the use of alternative herbicides, however, is that most herbicides are not inactivated on contact with the soil. Consequently, they have residual properties and can be toxic to the following crops. This is equally true of many of the herbicides used in cotton, in fallows and in rotation crops.

One result of this problem in the cotton cropping system is that many of the herbicides that are effective in fallows and rotation crops cannot be used because they are likely to be toxic to the following cotton crop. Weed control has been an issue in many of the rotation crops, and particularly in the broad-leaf rotation crops.

The CRDC and Cotton CRC have recently updated the Cotton Rotation Finder which provides a comprehensive matrix as to the different rotation crops available and their positive and negative impacts. The Cotton Rotation Finder can be found on the Cotton CRC web site.

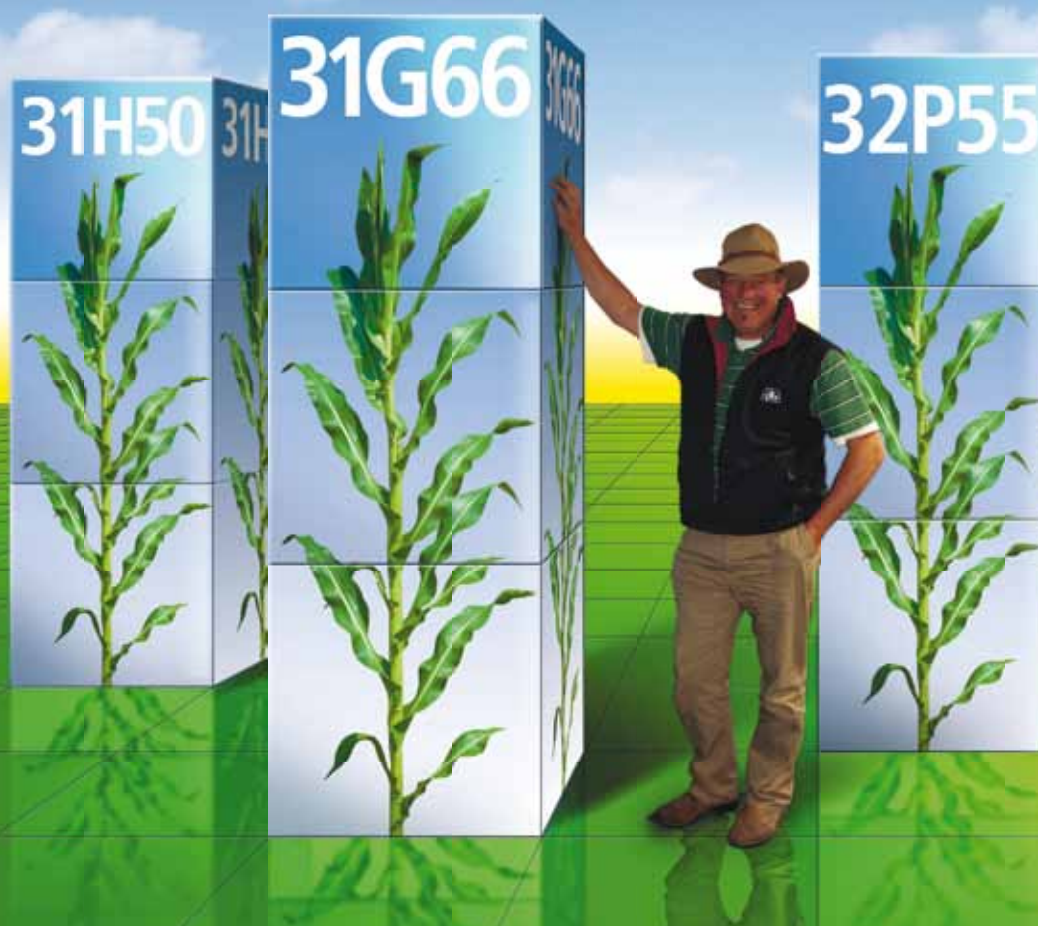
### Further information:

The Cotton Rotation Finder – [http://www.cottoncrc.org.au/content/Industry/Tools/Agronomy\\_Tools/Cotton\\_Rotation\\_Finder.aspx](http://www.cottoncrc.org.au/content/Industry/Tools/Agronomy_Tools/Cotton_Rotation_Finder.aspx)





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# Crop nutrition & soil health

By **DUNCAN WEIR & IAN ROCHESTER**

Acknowledgements: Nilantha Hulugalle (NSW I&I), Mike Bell (Qld DEEDI)



Duncan Weir.



Ian Rochester (CSIRO).

## Managing good soil nutrition

Crop nutrition management not only requires a sound knowledge about plant nutrient requirements and demands but also requires an understanding about soils, soil chemistry, soil health and the complex interaction between the plant and soil. Application of fertilisers to meet crop demand is only a part of developing a crop nutrition plan. Consideration must be given to other very important factors such as crop rotations, fallows, stubble management, tillage practices, legumes, manures and composts, soil chemistry, salinity, sodicity and irrigation water. The development of a considered, balanced nutrient management plan for the crop will maximise yields, optimise nutrient use efficiencies, minimise nutrient losses and improve soil health and physical properties.

Most of the nutrients taken up by cotton from the soil are derived from the decomposition of previous crop residues, soil microorganisms and soil organic matter.

## BE AWARE OF

**In developing a fertiliser program, a grower needs to**

- Determine soil nutrient status – soil sampling
- Calculate expected crop nutrient requirement
- Implement a fertiliser use plan – fertiliser form, rate, application, frequency, timing
- Monitor crop nutrient status – leaf (and petiole) analysis
- Develop a long-term crop nutrition and soil health management plan
- It is important that the fertiliser program begins before nutrient supply limits crop production.

Soil Health module in *myBMP* contains further information to support crop nutrition management

**TABLE 1.**

The amount of each nutrient removed at various yield levels.

| Yield<br>b/ha | N     | P  | K  | S  | Ca | Mg | B    | Cu | Zn  | Fe  | Mn |
|---------------|-------|----|----|----|----|----|------|----|-----|-----|----|
|               | kg/ha |    |    |    |    |    | g/ha |    |     |     |    |
| 4             | 35    | 10 | 15 | 4  | 2  | 5  | 13   | 12 | 53  | 85  | 6  |
| 5             | 50    | 12 | 18 | 5  | 3  | 7  | 20   | 14 | 63  | 98  | 8  |
| 6             | 65    | 14 | 22 | 6  | 3  | 8  | 28   | 16 | 72  | 112 | 9  |
| 7             | 80    | 17 | 26 | 7  | 4  | 10 | 35   | 18 | 82  | 125 | 11 |
| 8             | 95    | 19 | 29 | 8  | 4  | 11 | 42   | 20 | 91  | 138 | 12 |
| 9             | 110   | 21 | 33 | 9  | 5  | 13 | 49   | 22 | 100 | 151 | 14 |
| 10            | 125   | 24 | 37 | 10 | 6  | 14 | 56   | 24 | 110 | 164 | 15 |
| 11            | 140   | 26 | 41 | 11 | 6  | 16 | 63   | 26 | 119 | 178 | 17 |
| 12            | 155   | 28 | 44 | 12 | 7  | 17 | 70   | 28 | 129 | 191 | 18 |
| 13            | 170   | 31 | 48 | 13 | 7  | 19 | 78   | 30 | 138 | 204 | 20 |
| 14            | 185   | 33 | 52 | 14 | 8  | 20 | 85   | 32 | 148 | 217 | 21 |
| 15            | 200   | 35 | 55 | 16 | 8  | 22 | 92   | 34 | 157 | 230 | 22 |
| 16            | 215   | 37 | 59 | 17 | 9  | 23 | 99   | 36 | 166 | 244 | 24 |

<http://www.cottoncrc.org.au/files/4eab6e0b-514a-4eeb-94e8-995a00f90139/CGNutRem.pdf>

Nutrients are continually being cycled between the crop and soil, as occurs in all biological systems. However, because of the high rates of nutrient removal in seed cotton (Table 1), our inherently fertile cotton-growing soils can become depleted in nutrients.

The removal of nutrients depletes soil fertility and fertiliser application may be needed to increase the supply of these nutrients to subsequent cotton crops. Hence, we can either replace these nutrients as they are removed or wait until each nutrient successively becomes limiting to cotton production, then commence a fertiliser program to overcome the nutrient deficiency. It is important that this program begins before nutrient supply limits crop production.

Additional information is available in **NUTRIpak**, found on the Cotton CRC website. <http://www.cottoncrc.org.au/content/Industry/Publications/AgronomyNutrition/NUTRIpak.aspx>



Leaf analysis is a good way to find out about the nutritional status of your crop.

In developing a fertiliser program a grower needs to consider the following strategies and integrate them according to their own farm's needs:

- Determine soil nutrient status using pre-season soil testing
- Calculate expected crop nutrient requirement taking into consideration expected yield, cropping history, cropping system and nutrient losses, crop use efficiencies, plant nutrient recovery and uptake, soil condition and characteristics – decision support programs such as NutriLOGIC can assist here. ([www.CottASSIST.org.au](http://www.CottASSIST.org.au))
- Develop a fertiliser use plan that minimises nutrient losses
- Monitor crop through petiole (early season) and leaf analysis (flowering to defoliation) to determine if the crop has sufficient or inadequate nutrient levels
- Develop a long term management program which maintains or improves soil health.

## Determine soil nutrient status – soil sampling and analysis

A fundamental requirement in meeting the nutritional needs of a cotton crop is determining nutrient level in the soil before planting. By using soil analysis as a routine part of management, it can provide an indication of the fertility level in your soil at that point in time. Do-it-yourself soil sampling kits are commercially available through accredited laboratories or, service providers can be engaged to sample, analyse and provide recommendations for fertiliser application.

Soil sampling kits provide instructions on how and where to sample the soil in order to provide a representative sample. There are often differences in soils and soil types within any given field. To gain the most benefit from soil tests it is important to take these differences into account when sampling. Precision Ag technology such as EM surveys can assist to understand this variability. Crop performance throughout the season can also provide insight into areas worthy of investigation. Good records can allow for the monitoring of nutrient status over time. Follow sampling instructions carefully; accuracy of the results can be impaired if the samples are not taken and handled correctly.

*Refer to the Precision Ag section of this book for more details on EM surveys.*

When choosing a laboratory to conduct your testing, ensure that it is accredited to Australian Standards and registered by the Australian Association of Testing Authorities. Unfortunately laboratories express results differently so it is important that the tests being conducted are going to provide the information that is required and in a form that can be used.

**NB.** Link to soil sampling and analysis guidelines – CRC website <http://www.cottoncrc.org.au/files/0b13f3af-7ac6-4c68-910f-995a00f901b3/SamGL06.pdf>

## Calculate expected crop nutrient requirement

Interpreting soil tests can be complicated and it is recommended to seek professional advice from service providers or use an interpretation program such as NutriLOGIC to determine fertiliser requirements. NutriLOGIC is a user friendly decision aid for fertiliser management. It is a component of CottASSIST, a computerised support system developed by CSIRO and Cotton CRC to provide the cotton industry with access to the latest research.

*NutriLOGIC provides an assessment of nutrient/fertiliser requirements, independent of fertiliser manufacturers and resellers.*

NutriLOGIC estimates the fertiliser required for a cotton crop based on years of field experiments conducted in Australian conditions, supported by industry funding. Inputs required are soil test data, the cotton growing region and the month the sample was taken. The program makes allowance for soil factors (texture, compaction and predisposition to water logging). Losses of N through denitrification and leaching during the crop-growing season are also built into the program.

**NutriLOGIC can be accessed through CottASSIST at: [www.CottASSIST.cottoncrc.org.au/](http://www.CottASSIST.cottoncrc.org.au/)**

## Develop a fertiliser management plan

A fertiliser plan outlines how, when and in what form the fertiliser inputs that are required by cotton crops are managed. This requires working through a number of considerations, all of which depend on each other.

- **Which fertiliser to apply:** Different forms of fertiliser can be used i.e. manures and composts, granular fertilisers, anhydrous ammonia (gas), liquid fertiliser or foliar fertiliser. The type of fertiliser may be limited by the capacity to apply it. Composts and manures need to be spread and incorporated, anhydrous ammonia (gas) needs to be applied using specialised equipment by trained staff, and foliar fertilisers need to be applied evenly and in a timely manner, i.e. in response to nutrient crop demand.
- **When to apply:** The timing of fertiliser application is determined by the production system and the type of fertiliser being used. Composts and manures need to be spread and incorporated in advance of planting and when used in minimum tillage systems may need to be combined with other processes. Anhydrous ammonia (gas) fertiliser cannot be applied too close to planting as seedling damage may occur from ammonia burn. When applying all the nutritional requirements “up front” there are reduced efficiencies and greater losses from the system to be considered. Split applications can improve efficiencies and the application rates can be adjusted to meet changing crop demands. Timing of split applications is critical, irrigation and rain can impact on the capability to apply fertilisers in a timely manner hence increasing the risk of crops being nutrient deficient at a critical time.





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- **What rate to apply:** The fertiliser rate will depend on the type of fertiliser being used and when it is being applied. The composition of the fertiliser (percentage of each nutrient in the fertiliser) will dictate just how much of the product needs to be applied to meet the crop requirement. If all the fertiliser is being applied up front, an adjustment must be made to take into consideration losses and inefficiencies. On the other hand, if a starter fertiliser is being used at planting with later in-crop applications, the rate of fertiliser must be adjusted. The rate is determined by soil analysis in the winter prior to planting the crop and can be modified by leaf and petiole analyses performed in-crop.
- **Where to apply it:** Most fertilisers are best applied to the soil. This normally occurs pre-plant, at depth, off the plant line. Applying fertilisers too close to the plant line may cause seedling damage due to the salt or toxicity effect. Nitrogen, contained in fertilisers can be lost to the atmosphere through ammonia volatilisation and should be applied below the surface and buried. Other fertilisers e.g. P, K, Zn etc can be broadcast and then incorporated later to maximise contact between the roots and fertiliser. The amounts of nutrients that can be applied to the foliage is quite limited and the benefit short term. Foliar fertilisers can be used to help meet crop nutrient requirement when a nutrient has been identified and the quantity of nutrient required is small.

Fertiliser plans need to be flexible and have the capacity to be modified through the season if conditions change or if leaf and petiole analyses identify a problem and indicate a change to the nutritional requirement of the crop and subsequent fertiliser program.

## Monitor the crop

Often, nutrient deficiencies are not identified until symptoms appear, by which time, some yield reduction will have occurred despite remedial fertiliser application. Plant analyses can provide information about the nutritional status of a crop and indicate nutrient deficiencies which, if identified early enough, may be rectified by applying the appropriate fertiliser with little or no impact on the crop.

NutriLOGIC can be used to assess both petiole analysis (early crop nutrient monitoring) and leaf analysis (flowering to defoliation crop nutrient monitoring). Follow sampling direction carefully, results can only be as good as the sample provided.

More information about Leaf and Petiole Sampling and analysis can be found at: <http://www.cottoncra.org.au/content/Industry/Publications/AgronomyNutrition/NUTRIpak.aspx>

## Develop a long term management program which maintains or improves soil health

Compaction, sodicity, poor soil structure, low fertility and salinity are just some of the critically important reasons to develop long term production programs and systems. Sodicity and salinity are naturally accruing constraints in many soils used for cotton production. They are covered

in more detail in the Subsoil Constraints section below.

Reduced, minimal or zero tillage practices, crop rotations, cover crops, legumes, composts, stubble incorporation, manures and controlled traffic are just some of the management practices which can be introduced into a cropping system that can have beneficial impacts on soil health and soil fertility as well as reduce costs and improve productivity.

## Nutrients

### Nitrogen

Nitrogen is a mobile nutrient both in the soil and in the plant and should be monitored throughout the production season to maximise production. Deficiency symptoms include stunted plants with pale yellow leaves, few vegetative and fruiting branches. Excessive supply of N will induce rank vegetative growth, shed young bolls, delayed fruiting and crop maturity, hamper defoliation and reduce lint yield and profit. Insert Photos of deficiency symptoms

Cotton sources most of its N as nitrate-N from the mineralisation of soil organic matter. Mineralisation is a biological process within the soil which results in the release of nutrients in a form which is available for crop uptake. Only about 1/3 of the crop's N needs are derived from N fertiliser but this is critical to maximising production.

Nitrogen can be lost from the system in several ways and must be considered when preparing a nitrogen management plan. These include:

- Denitrification – a biological process especially under low oxygen conditions such as during water-logging where nitrate N is converted into a nitrogen gas and lost to the atmosphere.
- Leaching and runoff – nitrates can be washed through the soil profile and out of the root zone or removed in runoff water.
- Volatilisation – nitrogen in the form of ammonia is lost to the atmosphere. Particularly important when solid fertilisers are applied and are not incorporated properly or in a timely manner.
- Removal of seed cotton – most of the crop N removed from the system is found in the cotton seed and can be significant, particularly in high yielding crops.
- Burning stubble.

Excess nitrogen can have significant detrimental impacts on cotton. Rank vegetative growth, boll shedding, delayed full boll load and crop maturity, small fruit, increased disease problems such as boll rots, difficulties in defoliating, harvesting problems and reduced fibre quality are all problems associated from over fertilising. All these impacts have considerable economic costs associated with them and result in reduced yields, quality down grades, increased production costs as a result of increased use of growth regulators and defoliant, higher fertiliser costs and reduced N efficiencies.

Recent research on Nitrogen Use Efficiency (NUE) by Ian



Rochester has shown that many cotton crops are being over fertilised with nitrogen and significant improvements in NUE and the associated cost savings, could be achieved through the adoption of Best Management Practices.  
<https://www.mybmp.com.au/home.aspx>

For more detail of nutrient management and its impact on fibre quality: FIBREpak  
[http://www.cottoncra.org.au/content/Industry/Publications/Fibre\\_Quality/FIBREpak.aspx](http://www.cottoncra.org.au/content/Industry/Publications/Fibre_Quality/FIBREpak.aspx)

Anhydrous ammonia (82% N) and Urea (46% N) are the two major nitrogen fertilisers used in the cotton industry. The N released from both fertilisers become available to plants within days, depending on the amounts applied. Urea has the advantage of being able to be applied in different ways using different application methods and at different times. It does need to be incorporated quickly after application to prevent significant losses through volatilisation.

There are several different approaches to how and when N is applied. If all N is applied prior to planting:

- Apply after July to reduce substantial losses through denitrification and leaching.
- Allow sufficient time after application and before planting (3 weeks) to prevent seedling damage.
- Depth and position is also critical to prevent unnecessary losses and seedling damage.

If N applications are to be split there are two main methods (side-dressing and water run) of application in crop. Side-dressing should occur prior to flowering to help reduce crop damage through root pruning and allow sufficient time for the N to become available to the plant. Water run urea provides more flexibility and reduces crop damage.

Anhydrous ammonia (NH<sub>3</sub>) is the most popular option for irrigated cotton, especially where high rates of N are required. Specialised equipment and training is required when applying NH<sub>3</sub>. It must be applied deeper than 15cm to reduce losses however soil conditions impact greatly on this. Very dry soils will allow gas to escape through voids and air spaces while very wet soils will allow gas to escape through the application furrow if it is not closed properly.

## Legumes

Incorporating a legume into your crop rotations can significantly improve soil nitrogen fertility through their capacity to fix atmospheric nitrogen into a plant available form. Legumes can also have beneficial effects on soil structure and plant disease management. The amount N fixed and residual soil N of various legume crops can be seen in NUTRIpak. <http://www.cottoncra.org.au/files/bc8dee8e-3f68-4b2c-8c30-995a00f8ff3a/03N.pdf>

Recent work has shown significant financial and agronomic benefits of including legumes into the rotation. More detailed information can be found on the cotton CRC web site:

[http://www.cottoncra.org.au/files/c82c2fe2-f2c9-4c94-af82-9ad600bec0ca/Healthy%20Soils-VETCH%20\(Low%20Res\).pdf](http://www.cottoncra.org.au/files/c82c2fe2-f2c9-4c94-af82-9ad600bec0ca/Healthy%20Soils-VETCH%20(Low%20Res).pdf)

and

<http://www.cottoncra.org.au/files/fae55662-754b-4a81-922d-9a9000b7ca02/Vetch%20profits.pdf>

For more detail on the role of N, its importance, the nitrogen cycle and how it is managed follow the following links: <http://web.cottoncra.org.au/content/Industry/Publications/AgronomyNutrition/NUTRIpak.aspx>  
<http://web.cottoncra.org.au/files/bc8dee8e-3f68-4b2c-8c30-995a00f8ff3a/03N.pdf>  
<http://www.cottoncra.org.au/files/4eab6e0b-514a-4eeb-94e8-995a00f90139/CGNutRem.pdf>  
<http://www.cottoncra.org.au/files/e481c4ad-3fe5-4f36-9d61-9c63010dbf4d/FIBREpakweb.pdf>

## Phosphorus

Phosphorus (P) plays an important role in the energy transfer process in plants cells, used in DNA and RNA and some regulation of plant metabolism. Plant deficiency causes reduced seedling vigour, poor plant establishment and root development, delayed fruiting and maturity. Plants will appear stunted and with red/purplish colour.

Phosphorus is a highly immobile nutrient in the soil and despite many soils having a high total P content they can have very low P availability especially under alkaline conditions. P in soils can be classified into 3 pools:

- Available P (phosphate in soil solution that can be used by plants, limited in quantity but readily replenished from labile P).
- Labile P (moderately available P that move in and out of solution, acts to buffer the available P in solution).
- Non labile P (very insoluble P unavailable to plants). Mono Ammonium Phosphate, MAP (N:P:K – 9:22:0) and DiAmmonium Phosphate, DAP (N:P:K – 18:20:0) are the most commonly used P fertilisers. Banding of these fertilisers is the preferred method of application as the P remains in solution for a longer period. Although it is considered that P fertilisers are only 30–50% efficient, it is not lost to the system but is immobilised or fixed and may become available later.

P is relatively immobile within the soil so increasing soil-root contact can increase the uptake of P by the crop. Mycorrhizal fungi (VAM) found in the soil have an association with cotton and assist in accumulating and making P available to the plants. Low VAM populations have been attributed to long fallow disorder and need to be considered when growing cotton following long fallow periods or after non-mycorrhizal crops such as canola. Tillage is the main contributor to low VAM populations.

For more details on Phosphorus, its importance, the phosphorus cycle and how it is managed follow the links below:

Home Page for NUTRIpak

<http://web.cottoncra.org.au/content/Industry/Publications/AgronomyNutrition/NUTRIpak.aspx>

Phosphorous specific pages:

<http://www.cottoncra.org.au/files/91625ea6-5d78-4ba7-8d38-995a00f8ff64/04P.pdf>

## Potassium

Potassium (K) is a mobile nutrient within the plant and has a role in energy transfer, osmotic regulation (maintaining turgor), protein synthesis and nitrogen metabolism. Adequate K nutrition has been linked to

reducing the incidence or severity of plant diseases and improving yield and fibre quality.

Deficiencies are first seen in the lower leaves as necrotic lesions and leaf death which moves up the plant, bolls don't develop and fail to open, and as premature senescence can occur.

There are several forms of K in the soil with varying levels of availability to the plant.

Potassium chloride (muriate of potash) is the most widely used fertiliser. It should be banded away from the seed row to prevent seedling damage. Foliar fertilisers can be effective when deficiencies have been identified in petiole and leaf analysis.

For more details on K, its importance, the K cycle and how it is managed follow the links:

Home Page for NUTRIpak

<http://web.cottoncrc.org.au/content/Industry/Publications/AgronomyNutrition/NUTRIpak.aspx>

Potassium specific pages:

<http://www.cottoncrc.org.au/files/cf72d5c7-b1c5-4e12-9abe-995a00f8ff85/05K.pdf>

Related Topics:

Fibre Quality: [http://www.cottoncrc.org.au/content/Industry/Publications/Fibre\\_Quality/FIBREpak.aspx](http://www.cottoncrc.org.au/content/Industry/Publications/Fibre_Quality/FIBREpak.aspx)

## Other essential nutrients

**Zinc:** An essential nutrient required in small amounts for enzymes and plant hormone synthesis. Deficiencies can be seen as interveinal chlorosis, stunting, and will affect



Dark spots on yellow areas on the leaves are a sign of zinc deficiency.



Zinc deficient young leaves 'cup upwards' and develop interveinal yellowing.

yield, maturity and fibre quality. Zinc sulphate is the most effective and inexpensive form to apply zinc to soil or crop, whereas zinc oxide is very insoluble in the soil but can be dissolved by plant roots. Zinc can be broadcast and worked into the soil, with shallow cultivation. Zn can also be successfully applied to crops as a foliar spray; it can alleviate symptoms and supply sufficient zinc to meet crop needs.

**Iron:** Iron is an essential nutrient required in very small amounts in chlorophyll synthesis and some enzymes. Plant symptoms include interveinal chlorosis of the young growth and yellowing of the leaves. Most of the iron in soils is unavailable to plants. Availability is greatly affected by the presence of manganese and P and Zn fertiliser can also reduce iron uptake. Water logging can also lead to deficiencies in alkaline soils. Deficiencies can be managed through both foliar and soil applications. Other essential nutrients such as copper, boron, calcium, magnesium, sulphur, manganese and molybdenum all have very specific roles to play in meeting the nutritional needs of a cotton crop. Required in very small amount, deficiencies are very rare.

For more details on any of these minor nutrients, their importance, and how to manage them, follow the links:

<http://www.cottoncrc.org.au/content/Industry/Publications/AgronomyNutrition/NUTRIpak.aspx>

## Important links

<http://CottASSIST.cottoncrc.org.au/>

<http://www.cottoncrc.org.au/content/Industry/Publications/AgronomyNutrition/NUTRIpak.aspx>

[http://www.cottoncrc.org.au/content/Industry/Publications/Agronomy\\_Nutrition/Nutrition\\_\\_NUTRIpak.aspx](http://www.cottoncrc.org.au/content/Industry/Publications/Agronomy_Nutrition/Nutrition__NUTRIpak.aspx)

<http://www.dpi.nsw.gov.au/agriculture/resources/soils/guides/SOILpak/cotton>

<http://www.cottoncrc.org.au/content/Industry/Publications/Soils.aspx>

<https://www.mybmp.com.au/home.aspx>

## Subsoil constraints

Soil provides the cotton plant with water, oxygen, nutrients and support. An ideal soil would have good infiltration and internal drainage, high plant available water capacity (PAWC), good soil structure for root growth and development, optimum pH, low salinity, balance nutrient availability, low sodicity and adequate soil mycorrhiza and other soil biota. Subsoil constraints are those soil properties or characteristics which limit or restrict the cotton plant in meeting its requirements. Problems associated with subsoil constraints include compaction, soil dispersion, high or low pH, water logging and erosion. These soil related problems can result in poor seedling emergence, poor plant growth, loss of bolls and poor boll set, reduced yields, erosion, increased land management costs and other management issues.

Understanding how modern farming practices impact on and effect the soil, its chemical and physical properties, is a critical role in how we develop and manage our production systems. For example, as much as 1.5 tonnes of salt per ha is deposited onto soil and into the root zone each time a crop is irrigated. This is significantly higher when bore water is used rather than river water. The



accumulation of salts in the root zone can lead to sodic soils causing soil structural problems, soil dispersion, water logging and hard setting soils.

Best Management Practices have been outlined in the *myBMP* program and can be easily accessed on line on <http://www.bmpcotton.com.au/>

### What is a sodic soil?

A sodic soil is one which has too much sodium associated with the negatively charged clay particles. Large quantities of sodium in soil, reduces the strength of bonds holding clay particles together in aggregates. The sodium also attracts large numbers of water molecules helping to force the clay particles apart. This is known as dispersion and causes the soil structure to collapse. The level of sodicity can be quantified by determining the exchangeable sodium percentage (ESP) during a soil test. Many of the soils used for cotton production in Australia, are sodic or strongly sodic below a depth of 0.5 m. This affects root growth and water and nutrient uptake. Ground water, used for irrigation can cause sodicity problems particularly when the water contains high sodium levels relative to calcium.

### What is a saline soil?

A saline soil is one with excess salts in the soil solution. Soil solution is the liquid in soils held between the soil aggregates. When the concentration of salts in the soil solution exceeds that found in the plant roots, water flows from the roots back into the soil. In this situation the plant is unable to meet its water demands even though the soil is moist. Salinity occurs as a result of ground water rising to within 2mtr of the soil surface, or by irrigating with saline water, or by applying salts via: fertilisers; lime or gypsum. Salinity is measured by testing the soil solutions electrical conductivity (EC).

### Meeting the challenge of sodic soils

Calcium can be applied to soils to ameliorate sodic soils. The best form of calcium to use is determined by the pH of the soil. If the soil is alkaline, gypsum will give the best results while if the soil is acid, lime should be used. In this case, lime also has the added benefit of raising the pH of the soil.

The addition of organic matter to soil can also help to reduce the effects of soil sodicity. Organic matter helps hold the soil aggregates together, stabilises soil chemistry, reduces dispersion and improves soil structure.

Source: "Salinity and Sodicity – what's the difference?" By David McKenzie The Australian Cottongrower Feb-Mar 2003

Other sources of information on sodicity and salinity, their importance, impacts and management can be found on the Cotton CRC web sites:  
<http://www.cottoncrc.org.au/content/Industry/Publications/Soils.aspx>  
<http://www.dpi.nsw.gov.au/agriculture/resources/soils/guides/soilpak/cotton>  
[http://www.cottoncrc.org.au/content/Industry/Publications/Agronomy\\_Nutrition/Nutrition\\_\\_NUTRIpak.aspx](http://www.cottoncrc.org.au/content/Industry/Publications/Agronomy_Nutrition/Nutrition__NUTRIpak.aspx)  
[www.mybmp.com.au](http://www.mybmp.com.au)

### Other important soil constraints

**Compaction:** Soil compaction restricts root growth, reducing the availability of nutrients and water to the

cotton plant. It can also increase denitrification, further reducing the availability of nitrogen. Some compaction is an inevitable consequence of using heavy machinery on soils, however by implementing good management practices, minimal tillage systems and guidance systems, the impact can be minimised.

Overcoming soil compaction – advice can be found in SOILpak, see Website below.

More detail on soil compaction can be found on the Cotton CRC web site: [http://www.dpi.nsw.gov.au/\\_data/assets/pdf\\_file/0020/167501/soilpak-cotton-Part-E.pdf](http://www.dpi.nsw.gov.au/_data/assets/pdf_file/0020/167501/soilpak-cotton-Part-E.pdf)

**Waterlogging:** Water logging particularly following surface irrigation can impact significantly on cotton production. Denitrification, boll shed and reduced boll set are some of the impacts of water logging, resulting in yield loss. Water logging can be minimised by:

- Reducing irrigation times by increasing siphon flow rates
- Use shorter field lengths
- Have greater slopes in fields to increase the speed of the irrigation
- Insure beds in-field are raised
- Stop irrigation as soon as water reaches the tail drain
- Avoid soil compaction
- Use other irrigation systems i.e. lateral move or pivots

More details on water logging can be found on the Cotton CRC web site in SOILpak and NUTRIpak

[http://www.dpi.nsw.gov.au/\\_data/assets/pdf\\_file/0019/167500/soilpak-cotton-Part-D.pdf](http://www.dpi.nsw.gov.au/_data/assets/pdf_file/0019/167500/soilpak-cotton-Part-D.pdf)  
<http://www.cottoncrc.org.au/content/Industry/Publications/AgronomyNutrition/NUTRIpak.aspx>

**Soil pH:** Soil pH is a measure of the acidity, neutrality or alkalinity of the soil solution. It directly influences the availability of soil nutrients to the cotton plant. Most cracking clay soils are alkaline (pH 8.0 to 8.5) affecting the availability of many micronutrients. This should be considered when calculating fertiliser programs.

More details on soil pH can be found on the Cotton CRC web site in SOILpak and NUTRIpak  
<http://www.cottoncrc.org.au/content/Industry/Publications/AgronomyNutrition/NUTRIpak.aspx>  
[http://www.dpi.nsw.gov.au/\\_data/assets/pdf\\_file/0019/167500/soilpak-cotton-Part-D.pdf](http://www.dpi.nsw.gov.au/_data/assets/pdf_file/0019/167500/soilpak-cotton-Part-D.pdf)

**Soil mycorrhiza:** Soil mycorrhiza (also referred to as VAM), are beneficial soil-borne fungi that attach themselves to the growing roots of crops. They allow roots to scavenge more effectively for nutrients especially those nutrients which are immobile in the soil and have poor solubility such as P and Zn. Low VAM levels are associated with long fallow disorder when cotton crops perform poorly particular in long fallow dryland cotton systems or following non mycorrhizal crops such as canola.

More details on VAM can be found on the Cotton CRC web site in SOILpak and NUTRIpak  
<http://www.cottoncrc.org.au/content/Industry/Publications/AgronomyNutrition/NUTRIpak.aspx>  
<http://www.dpi.nsw.gov.au/agriculture/resources/soils/guides/soilpak/cotton>  
<http://www.cottoncrc.org.au/files/17c23902-844e-4a4a-b299-995c00488b84/Soilbiol.pdf>

# Crop water use

By LANCE PENDERGAST



Water is a production tool just like any other management input. Regardless of how growers manage their water or how much water is available the goal is to optimise water use efficiency (WUE). When the volume of available water is limited, improving water use efficiency involves a whole farm

water management plan.

The first step is to have a water budget. Water budgets consist of components such as crop / plant requirements, and potential water sources. Budgeting requires knowledge of all water sources; fallow rainfall and fallow efficiency, reliable in-crop rainfall, irrigation allocation and reticulated water. Water losses, such as by deep drainage and leaching in-field and through evaporation and seepage from on-farm storages and channels, should be also considered.

In the planning process, decisions about cropping and what area to sow can be made seasonally, dependent on expected water availability. Tools such as CropWaterUse – a web based application, is available to help growers calculate the theoretical daily and seasonal water use of a crop. (<http://cropwateruse.dpi.qld.gov.au>)

The overall production target must suit the type of irrigation system and the available water resource.

A successful philosophy to follow from the start is 'measure to manage'. The use of both water meters and soil moisture probes enables the fine tuning of management strategies that can lead to improved efficiencies.

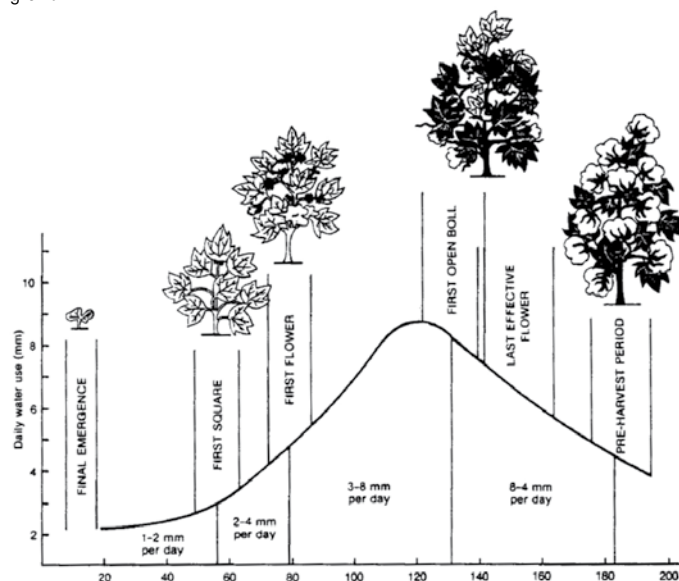
Dryland growers can use HowWet?, a Windows based program which uses farm rainfall records to estimate

## BE AWARE OF

- Measure to manage.
- The first irrigation is a balancing act between not stressing the plant while stored water is fully explored by the developing root system.
- For further support in all aspects of crop water use refer to the Water Management module in *myBMP*.
- Poor quality irrigation water causes reductions in cotton growth and degrades soil.
- Exposure to waterlogging, particularly at early stages of flowering, can significantly impact on yield.
- The prime objective of the last irrigation is to ensure that boll maturity is completed without water stress.
- Deep drainage reduces WUE.

**FIGURE 1.**

The changing scale of water use by the cotton plant as it moves into each stage of growth



how much plant available water has been stored in the soil and the amount of organic nitrogen that has been converted to an available form during a fallow (non-crop period). HowWet? tracks daily evaporation, runoff and soil moisture using estimates of weather conditions and rainfall input by the user. Accumulation of available nitrogen in the soil is calculated based on soil moisture, temperature, soil type and age of cultivation.

<http://www.apsru.gov.au/apsru/Products/HowWet/how%20wet.htm>

## Influence of row spacing on crop water use

For many years dryland growers have employed a variety of skip row configurations to successfully produce cotton. Choice of the appropriate configuration is largely dependant on the soil moisture available at planting, the timing and volume of anticipated in-crop rainfall, the machinery available, and both the options for risk management and the level of risk deemed acceptable by the individual grower.

Research trials have demonstrated that row spacing has a larger effect on yield and quality than number of plants per m of row. There is little or no yield reduction between 5 and 13 plants per metre. Gaps in plant stands should be avoided as they contribute to the production of large plants that are difficult to pick.

## Irrigation scheduling with limited water

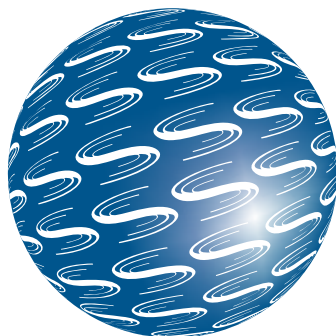
More recently, in the face of reduced water allocations that preclude normal (full) irrigation practises, irrigators have also employed skip row strategies into their production systems. As with dryland production, the number and timing of irrigations in skip row planted cotton will vary with location, soil type, previous history, and weather conditions, with the interval between irrigations increased with skip row plantings. Ideally the irrigation deficit used should be the same as for normal planting configuration.



# To measure is to know



- water savings
- improved yield
- improved quality



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For more information on row spacing refer to Chapter 7b 'Row configurations' of this publication and the following references:

'Row configuration' (WATERpak pg 145)

<http://www.cottoncrc.org.au/content/Industry/Publications/Water/WATERpak.aspx>

'Getting the most out of skip row irrigated cotton' (Cotton Seed Distributors Pty Ltd, 2009)

<http://www.csd.net.au/asset/send/2221/download/original/Getting%20the%20most%20out%20of%20skip%20row%20irrigated%20cotton.pdf>

## Water quality

"Crop production can decline if the salts in irrigation water exceed certain levels."

Poor quality irrigation water is enriched with salts and nutrients, and consequently its long-term use can cause soil degradation and reductions in cotton growth. These consequences can be minimised or avoided by vigilant crop and soil management, but this does involve additional costs (see pg 257 WATERpak).

As the quality of surface water (and bores) often varies

over time and between locations (and may affect the suitability of water for irrigation) it is important to monitor (simple and relatively inexpensive to do). Over 50% of cotton growers regularly monitor their irrigation water quality. The Water Quality tool on the Cotton CRC website can help growers make water shandyng decisions to dilute impacts of poorer quality bore water. This simple web tool can be used to calculate the salinity (EC), Sodium Adsorption Ratio (SAR) and pH when water sources are mixed together to provide irrigation water.

For further information refer to

"Assessing and managing irrigation salinity: including EM surveying" (WATERpak pg 235)

<http://www.cottoncrc.org.au/content/Industry/Publications/Water/WATERpak.aspx>

<http://CottASSIST.cottoncrc.org.au/WQC/About.aspx>

## Water logging

Because clay soils drain slowly, many cotton crops are subjected to some degree of waterlogging (see 'Field preparation' Chapter 7a). This problem is accentuated by rainfall after irrigation, cloudy conditions, and inadequate land preparation. Water logging may reduce crop yield by up to 1 bale/ha with yields affected before symptoms are noticed. Visual symptoms of waterlogged cotton include a general yellowing of the crop and stunted growth.

The major and immediate effect of waterlogging is a reduction in the transfer of oxygen between the roots and the soil atmosphere. Plant roots may become so oxygen deficient that they cannot respire. As a consequence, root growth and absorption of nutrients is decreased leading to less overall plant growth. A reduction in node numbers leads to a reduction in the number of fruiting sites and consequently a reduction in the number of bolls produced.

Cotton is most susceptible to waterlogging during the early stages of flowering as this is when the plant is setting the fruit load that will dictate final yield. As the plant gets older there will still be effects but they won't be as severe because the fruit is basically established on the plant.

Plants exposed to rainfall induced waterlogging may also suffer from the reduced sunlight availability associated with overcast conditions. Under these conditions the plant cannot fix enough carbon to maintain normal functions and may shed fruit as occurs under any other form of stress.

In addition to the immediate physiological impacts of waterlogging on the crop, there are also significant impacts on nutrient availability and uptake.

Waterlogging increases the rate of denitrification and plant uptake of Nitrogen (N), Iron (Fe), Zinc (Zn) (reduced) and Manganese (Mn) (increased) are directly affected by a decline in soil oxygen. Irrigation strategies designed to avoid potential waterlogging events not only contribute towards improved yield and water use efficiencies but can also benefit crop nutrient efficiencies.



Waterlogging also tends to decrease the plants ability to regulate sodium uptake and, although cotton is reasonably tolerant of salinity, exposure to increased concentrations does impinge on yield potential.

Optimised irrigation system designs allow delivery to the head-ditch, run-times and tailwater collection/return such that exposure to waterlogging and deep drainage are minimised.

## Pre irrigation

The decision for the cotton grower to pre-irrigate or water up the crop is, like so many others, a decision that has to be made specifically to suit a particular farm. In certain situations it can be beneficial to combine the two options: pre-irrigate to plant into moisture and give the crop a quick watering to ensure good plant stands” (WATERpak pg 91)

Every farm is different and a range of questions need to be considered before making a decision e.g. is it likely to rain before/during/after planting?, what are the implications associated with the different tactics in relation to seedling disease and weed control, am I set up for dry or moisture planting?

WATERpak provides a useful table outlining the pros and cons of pre irrigation (See Table 2. 10.2. Advantages and disadvantages of different options for the first irrigation) <http://www.cottoncra.org.au/content/Industry/Publications/Water/WATERpak.aspx>

## Scheduling in-crop irrigations

Irrigation scheduling is the decision of when and how much water to apply to an irrigated crop to maximise crop productivity. Good scheduling should provide plants with water that is within a desired range and should limit over or under irrigation so that balanced growth is achieved. For BollgardII varieties insufficient available water prior to and during flowering will reduce plant size and lead to early cut-out while too much water can lead to rank growth or waterlogging.

**The first irrigation** plays an important role in setting up for plant growth, fruit retention, fibre quality and boll weight. Its timing is perhaps the most difficult irrigation scheduling decision as it is a balancing act between not stressing the plant while stored water is fully explored by the developing root system.

The demands of high fruit retentions afforded by Bollgard II® cotton, in conjunction with tight water scenarios which growers and consultants have been faced with for the past few seasons, has seen the timing of first irrigation become a key management issue.

Irrigating too early can increase potential for exposure to waterlogging. Irrigating too late will incur yield penalties due to the impact of stress on plant development. Like many crops cotton has stages of development at which it is particularly sensitive to stress. Irrigation scheduling should strive to avoid exposure to stress during flowering and early boll filling stages. Research by Steve




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Yeates and Dirk Richards, CSIRO, in both BollgardII® and conventional cotton, has shown similar losses in yield attributed to being late on the first irrigation. Delaying the 1st irrigation will place the plant under stress which will impact on the performance of the crop. Results have shown a dramatic reduction in yield (up to 23%) due to stress in the lead up to flowering. Recent research by Marcelo Paytas and Steve Yeates has shown for BollgardII crops that when conditions are hot and dry irrigation up to 2 weeks prior to flowering on clay soils will increase yield provided there is no water stress after flowering.

It is important to tailor your irrigations to meet the needs of high retention crops to optimise yield and water use efficiency. High boll load early in flowering can lead to premature cut-out and lower yields.

## Subsequent irrigation scheduling

One of the most important things besides monitoring your soil moisture is monitoring crop development. Keep a check on squaring nodes, first position retention and NAWF. Use the Crop Development Tool on the CRC website ([www.cotton.crc.org.au](http://www.cotton.crc.org.au)) to help keep track of how the crop is progressing.

Research by Yeates has shown that low deficit scheduling or frequent watering eg 40 to 50mm deficit or 6 to 7 day intervals (Wee Waa clays) increased Bollgard II® yield by 17% and WUE by 8% when conditions were hot and dry during flowering. Trials showed where mild growing conditions were experienced, generally associated with higher in-crop rainfall and less evaporative demand, scheduling irrigations to a greater deficit maximised yield and WUE, by allowing the opportunity to capture more in-crop rainfall rather than irrigating at a 40mm deficit. Irrigation scheduling based on small deficits requires skill and a system that can apply water quickly. Otherwise application efficiencies will be lower and the crop waterlogged.

When irrigation water is limited, save water for the flowering period. Bollgard II® crops with high fruit retention are most susceptible to water stress late in flowering and at cut-out. Yeates and Richards have measured a yield decline of 2.7% per day of stress compared with 1.2% per day for conventional cotton at this stage of growth.

## Scheduling – final irrigation

Ideally the last irrigation will provide sufficient water to optimise final yield and fibre quality, adequate soil moisture to facilitate efficient take-up and function of applied defoliant, and a soil profile that is sufficiently dry enough to enable harvest without causing soil compaction.

End of season water requirements can be estimated from the date of the last effective flower ('cut-out'). Although location specific it takes about 50 days from cut out to maturity. Given reduced daily water use late in growth and a full profile, a crop should be able to rely on stored

soil water for up to 30 days, on most clay soils depending on the rate of evapotranspiration experienced. Hence irrigation water is required for the first 20–25 days after last effective flower – possibly two irrigations would be required during this time. The last harvestable bolls take 600 to 650 day degrees to reach maturity. Crop water use during this period will vary, at the time of first open boll, water use may be 5–7mm/day, and may decline to around 3–4mm/day prior to defoliation.

There are a number of methods available to accurately time final irrigation and defoliation: Measuring Nodes Above (last) Cracked Boll (NACB), is most commonly used [www.cottoncrc.org.au/files/0f2a74ed.../Fp11\\_Open\\_Boll\\_to\\_Harvest.pdf](http://www.cottoncrc.org.au/files/0f2a74ed.../Fp11_Open_Boll_to_Harvest.pdf). On average, bolls will sequentially open at a rate of a node every three days. This will depend on a number of factors, particularly climatic conditions.

"The prime objection of the last irrigation is to ensure that boll maturity is completed without water stress" (WATERpak pg 93). Once a boll is 10–14 days old, the abscission layer responsible for boll-shed cannot form. Consequently late water stress (beyond cut out) does not significantly reduce boll numbers and therefore yield. However, fibre quality can be more seriously affected by late water stress. Crops that come under stress prior to defoliation (60% bolls open or 4 boll carrying NACB), can suffer some fibre quality reduction, especially micronaire. The degree of reduction obviously increases the earlier the stress occurs.

The author would like to acknowledge that this article relies extensively on original contributions to WATERpak by Nilantha Hulugalle, Mike Bange, Steve Yeates, Dirk Richards, Guy Roth, Dallas Gibb and Stefan Henggeler

For more Information: <http://www.cottoncrc.org.au/content/Industry/Publications/Water/WATERpak.aspx>



# Whole farm water balance

By **JIM PURCELL**, Aquatech Consulting  
Narrabri & Warren

## One of the keys to better water management



A successful and profitable irrigation enterprise is one that manages precious water at both the crop root zone level (soil moisture monitoring and irrigation scheduling) and at the whole farm level – How much water do I have? What are my losses? and, Therefore how much do I have left for crop production?

This section discusses the whole farm water management area. The tools for whole farm water balance have progressed greatly in the past 10 years. The use of commercial tools and water management consulting services has steadily grown as irrigators strive to improve their profitability with less water.

Below is a step by step process to better manage water at the whole farm level. In summary:

### Phase 1

- Measure and record the basics.
- Complete a simple seasonal whole farm water balance.
- Review the results.
- Fix the easy stuff.
- Repeat until happy

## BE AWARE OF

- Not only does water need to be managed in the crop root zone but also at the whole farm level.
- Key measurement is needed to complete any water balance.
- Water losses can best be identified and then reduced by completing a whole farm water balance.
- Measuring equipment and easy to use software packages are now commercially available to complete seasonal and even daily whole farm water balances.
- Water balance and improved water use efficiency can be done in stages starting with the very easy and work through at your own pace.
- Do not chase accuracy for accuracy's sake. A good estimate is better than nothing.

### Phase 2

- Stop at Phase 1 if you are happy with your WUE or move to daily water balance. Daily water balance allows prediction forward of water requirements before and during the season.

## Phase 1 – Seasonal whole farm water balance

### Step 1 – Measurement

Measurement is essential for any good management and water management is no different. To achieve good measurement start with the following:

- Ensure all water meters are installed correctly and measuring accurately. Check them with another meter.
- Survey all storages to establish accurate depth to volume to surface area characteristics. Ensure all tailwater and buffer storages are included. Storage surveys can now be done with water in the storages!
- Fit storage meters in all storages. Gauge Boards are a start but don't really do enough. It is very difficult to measure the volume of a stormwater harvesting event with gauge boards unless the gauge boards are read just before and just after each event and recorded. Irrimate™ Storage Meters have been developed over the past 5–6 years. They read and log water level, storage volume and water surface area at any required interval (normally 30 minutes but can be changed). This not only allows water volume to be accurately monitored in real time but also provides flow rates into or out of the storage. A storage meter also records the water surface area which allows the calculation of water volume loss from seepage and evaporation. Telemetry is now optional with information available by internet (read your storage volume, depth and surface area while on a holiday overseas!).
- Take strategic measurements of soil seepage characteristics and storage and channel evaporation characteristics. This allows calculation of the seepage and evaporation losses in each storage, channel and drain. Irrimate™ Seepage and Evaporation Meters can be hired from Aquatech Consulting or any Irrimate™ Agent. These meters measure both seepage and evaporation characteristics. It is not necessary to measure every storage or every channel and drain to get meaningful results.

### Step 2 – Record keeping

The next step is basic record keeping. The aim is to provide enough information to be able to complete a seasonal water balance. Enough basic information is required to calculate accurately how much water the crop actually needed during the particular season and how much water was made available to grow that crop.

In simple terms, the total measured available water, less the calculated actual crop water requirements for the season, equals the water lost to production. It should always be remembered that it is impossible to produce an irrigated crop without some losses. The real question is "How much lost water can be saved and used to increase production and profit?"

To establish this, it is necessary to be able to split up the total water lost to production into components:

- Storages losses (wet-up, seepage and evaporation).
- Channel system losses.
- Drainage system losses.
- In-field losses.
- Operational losses (stuff-ups resulting in water lost out of the system).

The records needed for a seasonal whole farm water balance include:

- Meter readings from all inflows – (river, scheme channel and/or bores).
- Storage volumes at the start of the season.
- Storage volumes at the end of the season.
- Harvested water volumes (land surface diversions) measured using the Irrimate™ storage meters or similar.
- Rainfall on fields.
- Field number or name and area.
- Crop yield.
- Reference Evapotranspiration for each day during season (automatically provided in WaterTrack™).
- Field soil type (menus provided).
- Field soil moisture deficits (mm) at the start of the season and end of season (estimated or from soil probes if available).
- Crop emergence date and end date (when crop stops transpiring e.g. cotton defoliation).
- Dates of each field irrigation.

### Step 3 – Seasonal water balance

The whole point of completing a whole farm water balance is to find out where water is being lost, whether those losses are ok and what is required to reduce the losses and increase production.

The Seepage and Evaporation Assessment with an Irrimate™ Meter allows the calculation of soil seepage losses from storages, channels and drains. Similarly, the measured evaporation characteristics from the same measurement allow calculation of evaporation from storages, channels and drains. If a farm has two different soil types, then it 'may' be necessary to complete a second Seepage and Evaporation Assessment in each soil type.

Calculation of actual crop water requirements is based on daily Reference Evapotranspiration (Eto) values for the particular farm and season and crop factors. Eto can be sourced from a weather station on the farm or normally from the Bureau of Meteorology SILO database. If WaterTrack™ is used for the whole farm water balance, the program automatically obtains and updates daily Eto from the Bureau of Meteorology. All that is required is to provide the farm Latitude and Longitude from Google Earth.

### Step 4 – Review the results

All irrigation farms will lose water; it is inevitable. The question is "Where are the losses and are they OK?"

WaterTrack Divider™ will complete a simple seasonal water balance and provide Water Use Efficiency Indices

required for myBMP and Water Management Plans.

Irrigation consultants can advise whether the losses are typical, good or bad and can advise on the type of works and cost to reduce losses. WaterTrack Divider™ even provides a basic economic calculator. This can determine if the proposed capital works are economic and how long the pay back period is from the extra production.

There is a network of commercial consultants from Emerald, Queensland to Keith in South Australia who can provide the equipment, software and consulting support to their clients in Water Management and is significantly increasing profit for farmers.

### Step 5 – Repeat seasonal water balance next season and so on, until happy with reduced losses and water use efficiency performance

For more detailed accuracy and predictions undertake Phase 2.

## Phase 2 – Daily whole farm water balance

### Step 6 – Comprehensive daily whole farm water balance

Rather than waiting until the end of the season to check how water management went, it is also possible to set up the daily water balance model, WaterTrack Optimiser™.

WaterTrack Optimiser™ models each element of an irrigation farm in sections and in individual fields daily. The computer model replicates each action taken by the irrigator in his/her daily routine and calculates the losses in each segment of channel and drain, each storage and each field daily.

The results are much more comprehensive than those achieved by completing a seasonal water balance but more effort is required with data collection and data entry. Essentially, every action done with water on the farm is also done on the computer.

The value of the extra effort is the ability to manage water at each irrigation rather than next season. WaterTrack Optimiser™ also allows forward prediction at any time to check whether there is enough water available (including losses) to completely irrigate those fields in production.

Typically, prediction is done:

- Before planting.
- Mid November or early December to decide which fields shall remain irrigated.
- As many times as required in February to determine which fields shall be finished.

The effort required to complete this modelling can result in very significant profit increases by maximising the yield potential of the remaining water. Most irrigators use commercial consultants to complete this modelling. The consultant is then able to work with the irrigator on alternative strategies.

For more information contact: Aquatech Consulting 02 6792 1265, [www.irrimate.com.au](http://www.irrimate.com.au) or [www.watertrack.com.au](http://www.watertrack.com.au)



# Alternative irrigation systems

By **LANCE PENDERGAST**

## Centre Pivots/Lateral Moves (CPLM)



Centre pivot and lateral moves (CPLMs), have been around since the 1950s, and used by American cotton growers from the late 1960s. Their design was still relatively basic when first introduced to the Australian cotton industry in the early 1970s. Early experiences with CPLMs were often poor.

Typically early Australian system designs, based on American experience, were incapable of delivering the application rates required by cotton growing under Australia conditions, a problem exacerbated by the relative lack of knowledge regarding peak crop water use. They operated at high pressure using overhead knocker sprinklers and were prone to poor hydraulic design. Operating costs were high, water use efficiencies low and a great deal of time was spent just keeping the systems going. Much has changed since those early days. Pressure on water availability and environmental sustainability, as well as economic and political factors, have contributed to increasing attention to the viability of CPLMs. Raine, Foley and Henkel (2000) found less than 4% of Australian cotton grown under CPLMs. A study currently underway will no doubt record a significantly greater area irrigated with CPLMs today.

Design and operating protocols have come a long way in the past decade. Systems capable of operating efficiently



**Swing arm pivot in operation.**

over a wide range of soil types and environmental conditions now efficiently irrigate an increasing area of cotton.

Before replacing a current surface irrigation system with a CPLM system you should assess the performance of the existing system. This will ascertain potential improvements before considering the alternative irrigation systems. Optimisation of an existing furrow system could significantly reduce potential gains expected from investment in an alternative system.

It is not possible to make a 'rule-of-thumb' statement that the investment in CPLMs is or is not profitable – every farm business differs and so do the water savings and yield benefits for the many crops that can be grown with these machines.

A 'with' and 'without' scenario analysis approach with support from a suitably qualified agri-business financial advisor, is a robust method to assess the economic and financial performance of investment in CPLMs. This approach involves the following steps:

- Prepare a steady state profit analysis at the whole farm scale for the current farming system (the 'without' scenario) and the one with the CPLM investment (the 'with' scenario).
- Undertake a financial analysis over the life of the investment for the 'with' and 'without' scenarios.
- Complete an economic analysis to calculate and compare the Internal Rate of Return and the Net Present Values for the 'with' and 'without' scenarios.
- Perform a marginal analysis to calculate the marginal return and payback period for the CPLM investment.

Growers considering purchasing CPLMs should look, listen and learn from those with experience with these machines. One of the most consistent messages is the importance of obtaining a 'site specific' system design – CPLM designs must be tailored to match the environment (e.g. soil characteristics) in which they will be operating. Field by field considerations often result in system design varying considerably between machines operating in close proximity to each other.

### BE AWARE OF

- CPLM are capable of profitably producing cotton.
- Their design needs to be site-specific.
- They should only be considered when the potential performance of any existing system (e.g. furrow) has been adequately assessed.
- When assessing the viability of CPLM investments the following need to be considered: Yield and prices risk, the extent of water savings and risk of water availability, likely impact of changing energy costs, and availability of labour.

A well designed CPLM should:

- Maximise the amount of water placed into the crop root zone from water pumped.
- Distribute the water uniformly across the field.
- Be capable of meeting peak crop water use.
- Have minimal energy and labour inputs.

Fortunately the industry has matured since its early days when disappointment could often be traced back to inappropriate designs sold and built by overly “optimistic” providers. Growers can now access providers with a proven track record of delivering machines that perform as promised. A range of tools has been developed to assist growers’ initial decision making process, to verify system performance, and to plan ongoing machine operation. These are now available through the Cotton Catchment Communities CRC and other industry bodies.

## Useful resources

- The cotton industry publication WATERpak provides a useful discussion of alternative irrigation systems, including CPLMs.
- A comprehensive CPLM training package, developed and delivered by the National Centre for Engineering in Agriculture (NCEA) with funding from CRDC and the CRC-IF.
- A Centre Pivot and Lateral Move one day workshop available through Growcom.
- Water Use Efficiency extension officers, funded by Australian Government’s Water for the Future Program and the Rural Water Use Efficiency 4 project, can provide assistance to access information.
- OVERshed – an on-line CPLM management tool for visualising soil moisture deficits and irrigation scheduling options.

## Subsurface drip irrigation

### BE AWARE OF

- SDI has more flexibility in design layouts than surface irrigation systems.
- Any decision to invest in SDI should be underpinned by many of the same considerations associated with investing in CPLM technology.
- As with CPLM the decision making process to invest in SDI needs to be supported by a ‘with’ and ‘without’ scenario analysis approach.
- More expensive than CPLM and requires a higher level of operator expertise if potential benefits are to be achieved.

Furrow irrigation remains the dominant irrigation method in Australia. Typically about 60–70% of the water that reaches the field is used by the crop, and the remainder is recycled as runoff or lost to deep

drainage. Over recent years some operators have made considerable improvements in the efficiency of furrow irrigation in response to the increasing demand for limited water supplies. Significant improvements in water use efficiencies have been achieved through furrow optimisation evaluations using advance meters, siphon meters and SIRMOD. There has also been an increased adoption of CPLM systems. While irrigation efficiency for these systems is often higher (85–90%) than for furrow (about 75–85%), there is still the potential for losses due to evaporation and increased foliar diseases. Improved designs of both machines and sprinklers, and innovations such as the use of low energy precision applications have led to some operations increasing water use efficiency to exceed 90% (with associated improvements in application uniformity).

Sub-surface drip irrigation (SDI) is an alternative irrigation system for improving water use efficiency and has been successfully used by Australian cotton producers. SDI is the application of water below the soil surface through emitters with a discharge equivalent to crop water requirements – to meet the crop evapo-transpiration demand. It is a low pressure, low volume irrigation system that uses buried drip tubes. SDI tape is laid permanently and has been documented lasting for 10–15 years. Recent developments in SDI technologies and materials have increased system affordability and reliability with systems now capable of achieving irrigation efficiencies as high as 90–100%.

Capital investment and labor costs are, therefore, low compared to surface drip where tape needs to be placed, removed and then replaced after each crop. It has a number of potential benefits over furrow irrigation:

- Water savings, control of runoff and deep drainage, increased rainfall capture, and reduced soil surface evaporation.
- Reduced incidence of disease and weeds.
- Enhanced fertiliser efficiency.
- Reduced labor demands.
- Field operations possible even when the irrigation is turned on.

As was the case with CPLM, historically SDI irrigated cotton systems provided disappointing results. Their failure to produce the anticipated improvements in yield and water use efficiencies (which had been critical components in the initial decision to outlay the considerable required installation capital) may be attributed to a range of factors. Again, as with early CPLM installations, poor design or adherence to design at installation, and insufficient operator expertise, so often associated with application of any new technology, did little to produce expected outcomes. Just as a high performance engine behaves atrociously when out of tune, SDI systems perform poorly if not operated correctly, even if their design is excellent.

Trials conducted by the Cotton Catchments Communities CRC, in collaboration with a tape manufacturer and three





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irrigators on three sites, (see Table 1.) showed a range of yield impacts of drip irrigation on cotton. The average yield decreased with the use of drip at one site (although here drip out-yielded furrow irrigated cotton in the first year of installation), and increased at the second (a 10% yield increase on average over furrow irrigation with 1m drip) and third sites (where yield increases ranging from 20 to 34% for drip over furrow irrigation where recorded). The average reduction in applied irrigation for drip irrigation over furrow irrigation ranged from 15 to 31% across the three demonstration sites.

**TABLE 1.**

Impact of drip irrigation on Water Use Efficiency Indices (bales/ML) on three Darling Downs drip irrigation demonstration sites.

|                  | Gross Production Water Use Index (GPWUI) |      | Irrigation Water Use Index (IWUI) |      |
|------------------|------------------------------------------|------|-----------------------------------|------|
|                  | Furrow                                   | Drip | Furrow                            | Drip |
| Site 1 (1m drip) | 0.84                                     | 1.11 | 1.58                              | 2.60 |
| (2m drip)        | 0.84                                     | 1.04 | 1.58                              | 2.41 |
| Site 2 (solid)   | 1.22                                     | 1.30 | 2.20                              | 2.80 |
| (skip)           | 1.32                                     | 1.50 | 2.19                              | 2.66 |
| Site 3 (60")     | 1.13                                     | 1.82 | 1.66                              | 2.69 |
| (skip)           | 0.92                                     | 1.15 | 2.24                              | 3.17 |

The impacts of the yield increases and reduction in water use, as captured in the Water Use Efficiency Indices (IWUE – bales/ML), showed significant improvements in water use efficiency from the investment in drip irrigation. However, for an increase in profitability from the installation of drip the water savings must be significant enough to enable an expansion in cotton area and an increase in yield sufficient to increase profits over the existing furrow irrigation system.

It is also important that there is reliability in water supply from year to year to justify the significant capital investment. It is critical that best management practices in design, installation, management and maintenance of drip irrigation systems are followed – if not, then profitable investment in these systems is unattainable.

### Useful resources

CRDC funded, NCEA produced publication: *Alternative Irrigation Systems for the Australian Cotton Industry* by Raine, Foley and Henkel remains a very informative reference for both SDI and CPLM. Ask your local cotton or water use efficiency extension officer for access to a copy.

More Profit Per Drop (<http://moreprofitperdrop.wordpress.com>) website has a range of articles discussing SDI.

Articles discussing SDI can also be accessed at <http://www.cottonandgrains.irrigationfutures.org.au> including WATERpak provides a useful discussion of alternative irrigation systems, including SDI.

## Bankless irrigation systems

By Nikki Pilcher, DEEDI

### BE AWARE OF

- Bankless channel irrigation systems are a new system being utilised within the industry.
- The major benefit and motivator for change to this system is reduced labour requirements.
- Efficiencies of these systems still need to be assessed.
- Expensive to convert an existing irrigation system to a bankless system.

Bankless channel systems are designed to remove the need for siphons, with the field split into bays. The field is designed to be watered at a high flow rate with all furrows in a bay irrigated at once

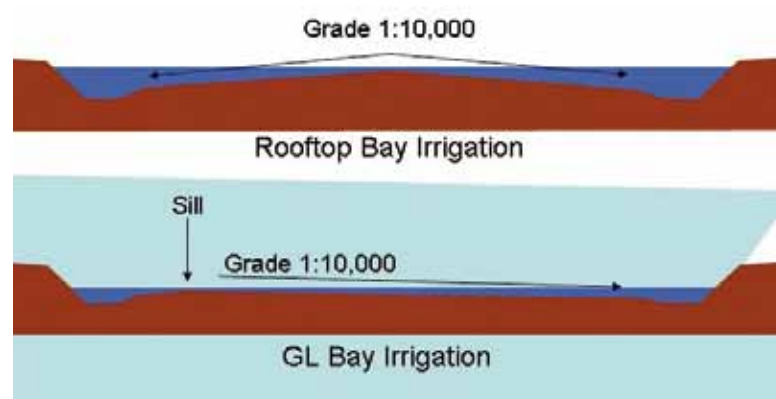
There are several types of bankless channel systems in use in Queensland and NSW. The original bankless channel system is the 'roof-top' system. In the roof-top system the bay is graded from both ends on a reverse slope forming a peak in the centre of each bay. Innovations in design are being made with this design with the most recent version in the St George area eliminating the roof top configuration.

Currently there is work in NSW measuring the efficiencies and variability of bankless channel systems. In the 2011–12 season the DEEDI Irrigation Extension team intend building on past research in the St George area by developing a strategy to assess the efficiency of the bankless systems in that district.

Bankless irrigation systems are being used by broadacre irrigators seeking to improve farm efficiencies. The main motivation is the labour savings that can be made with such a system.

### Pros

- Reduced labour requirements through removal of siphons.
- Improved machinery efficiency – no need for



Two different bankless channel field designs – GL Bays have superseded the rooftop on a property near St George. (Source: GL Irrigation)



traditional management operations such as rotobuckling and drive through ditches for spraying and harvesting operations.

- Ability to better manage crop water use in response to hot, dry weather and pending rainfall events.
- Limited maintenance – tail drains are graded every 2–3 years but no need to do head ditches.

### Cons

- Not suitable for paddocks with varying soil types.
- Current efficiency and uniformity evaluation methods not suitable to assess bankless systems.
- Need suitable slopes.
- Installation costs – suited to properties in the developmental phase as opposed to converting old siphon fields to bankless systems.

For more information contact: [nikki.a.pilcher@deedi.qld.gov.au](mailto:nikki.a.pilcher@deedi.qld.gov.au)  
Ph: 07 4620 8109, Mob: 0428 114 810.



Looking down the furrows on a bankless channel bay near St George.



Check gates being removed between bays at a property near St George on a bankless channel system.



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*Best Practice*





# Spray applications for cotton

By **BILL GORDON & GRAHAM BETTS**



Bill Gordon.



Graham Betts.

## Calculating banded sprays

Often people want to know the actual application rate and how much chemical to put in the tank (based on green ha or sprayed ha), how far a tank will go (based on paddock ha) and what rate to put in the spray controller. Others want to know what nozzles they should use to achieve a recommendation they have received from their advisor.

There are often big differences between the consultant's recommendation, the applicator's instincts and what the machine can actually do with the nozzles available.

The main reason for a banded application is to place the recommended rate of the product onto an area smaller than the whole field (this way we use less chemical over the whole field, but still apply the equivalent rate/ha to the actual target area).

To work out the true application rate we need to know the sprayed width, or average sprayed width for each nozzle, this allows us to calculate the litres per sprayed ha (L/sprayed ha sometimes called L/green ha). Label rates are always given as L/sprayed ha. Advisors should always give recommendations as L/sprayed ha.

To apply the correct L/sprayed ha there are two main things to work out:

- **How much chemical to put in the tank**, which is based on L/sprayed ha.
- **What to put into a controller**, which is based on

## BE AWARE OF

- Even the most experienced operators can be concerned about the accuracy of banded applications.
- Advisors should always give recommendations as L/sprayed ha.
- Ensure the right rates go to the target.

paddock ha per tank, (unless you want to play around with section widths).

## Formula

(the following are a selection, there are many that work)

- Band width in metres: **eg 0.7m band**  $\div$  1 m row spacing = band width (m)  $\div$  row spacing (m).
- Sprayed width per nozzle (m): = **band width (m)  $\div$  number nozzles per band** (eg 3 nozzles per 70% band of a 1 m row =  $0.7 \text{ m} \div 3 = 0.23\text{m}$ ).
- The application rate = **L/sprayed ha: L/sprayed ha = L/min/nozzle  $\times$  600  $\div$  speed (km/h)  $\div$  sprayed width per nozzle (m).**

L/sprayed ha applies to each band (row), whether you spray 1 band (row), or many rows, whether it is a solid plant, single skip or double skip.

- Number of sprayed ha per tank = **Tank size (L)  $\div$  L/sprayed ha.**
- Amount of chemical to add per tank = **Sprayed ha per tank  $\times$  chemical rate/ha.**
- Paddock ha per tank (solid plant): = **Sprayed ha per tank  $\div$  band width (m).**
- Paddock ha per tank (Skip Row Configurations):  
eg Double Skip on 1m row spacing (only planted 1 out of every 2 rows), this would be the same as only spraying 12  $\times$  1m rows with a 24m boom.  
**Paddock ha per tank (skip) = Sprayed ha per tank  $\div$  the band width (m)  $\times$  width of boom  $\div$  row width (m)  $\div$  number of planted rows under the boom.**
- Rate to put in the Controller: = **Tank Size (L)  $\div$  Paddock ha per tank**  
\*this works if you don't want to change the section widths in the controller.

## Selecting the correct nozzle size for a particular job

To work out what size nozzles you need to get a particular L/sprayed ha, you need to know what the required flow rate of each nozzle (L/min/nozzle) should be.

If all nozzles are the same size this is relatively easy, as the flow rate will be the same for each nozzle. For example the average sprayed width per nozzle if you had 5 nozzles per 1 m row at 100% band would be  $1\text{m} \div 4 = 0.2\text{m}$ .

If you had 4 nozzles per 1m row and a 70% band, then

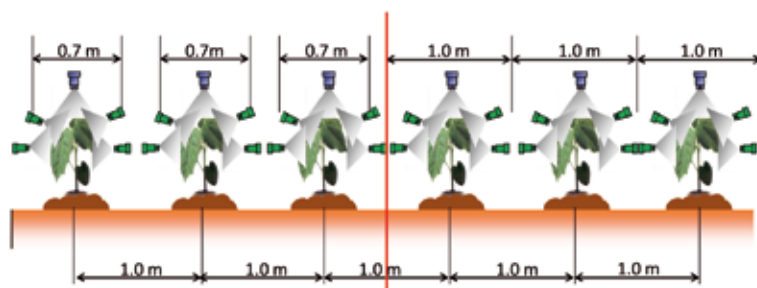


Diagram courtesy of Graham Betts.



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– Hamish Johnstone

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the average sprayed width would be  $0.7\text{m} \div 5 = 0.14\text{m}$ .

To calculate the required flow rate of each nozzle, the formula you need to use is:

**$L/\text{min}/\text{nozzle} = L/\text{sprayed ha} \div 600 \times \text{speed (km/h)} \times \text{average width of each nozzle (m)}$**

If you are using different combinations of nozzle sizes, you can still use the same formula, but it helps to work out the total flow rate for each band (or row), to do this, change the average width per nozzle to the band width or spray width per band (row) to get the total flow required per band (or row) and select nozzles with flow rates that add up to that total (all at the same pressure).

Once you have calculated the required L/min/nozzle use a nozzle flow chart to identify appropriate nozzle sizes and pressures, and don't forget to check the spray quality produced to ensure it is consistent with the product label.

For further information, there is an easy-to-follow publication (by Graham Betts – “banded spraying” booklet) that has all the necessary diagrams and tables to make banded application easy – it will take you through many situations explaining the calculations and how to choose nozzles for different jobs.

To purchase a copy of the publication, contact Graham Betts at ASK GB Mobile 0427 622 214 <mailto:askgb@bigpond.com>

Bill Gordon has worked closely with the cotton and grains industry for many years and runs workshops for farmers and trainers. Contact Bill Gordon Consulting 0429 976 565 <mailto:bill.gordon@bigpond.com>

The information on the following pages is courtesy of NuFarm Australia Ltd: 03 9282 1000, [www.nufarm.com.au](http://www.nufarm.com.au)



# Boom Spray Hygiene Cleaning procedure



| GROUP | CHEMISTRY                                    | PRODUCTS                                                                                                                     | CLEANING PRODUCT                                             |
|-------|----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|
| A     | Dims                                         | Sequence                                                                                                                     | Tank and Equipment Cleaner                                   |
|       | Fops                                         | Nugrass                                                                                                                      |                                                              |
| B     | Imidazolinones                               | Midas®<br>Arsenal Xpress, Spinnaker<br>Intervix®, Raptor®                                                                    | Small amount of Tank and<br>Equipment Cleaner or water       |
|       | Sulfonyl Ureas                               | Associate®, Lusta®, Monza®<br>Nugran®, Semptra                                                                               | Chlorine Beach                                               |
| C     | Triazines                                    | Nu-Trazine 900 DF Convoy® DF<br>Diuron 900 DF                                                                                |                                                              |
|       |                                              | Flowable Diuron, Flowable Simazine                                                                                           |                                                              |
|       |                                              | Nu-Tron 900 Df, Prometyrn 900 DF,<br>Simazine                                                                                |                                                              |
|       | Benzonitriles                                | Bromicide 200                                                                                                                |                                                              |
| D     | Dinitroanilines                              | TriflurX, Rifle 440                                                                                                          |                                                              |
| F     | Phenoxynicotinanilides                       | Paragon, Nugrex                                                                                                              |                                                              |
| G     | Diphenyl Ethers<br>Triololinones             | Striker, Affinity®, Hammer®                                                                                                  | Alkaline Detergent 'Omo®' or 'Spree®'                        |
| I     | Benzoic Acids                                | Kamba 500, Comet 200, Conqueror                                                                                              | Tank and Equipment Cleaner                                   |
|       |                                              | Invader 600                                                                                                                  |                                                              |
|       | Phenoxy Acetic Acids                         |                                                                                                                              |                                                              |
|       | Mcpa (Dimethylamine)                         | Agritone 750                                                                                                                 | Cloudy Ammonia followed by Tank and<br>Equipment Cleaner     |
|       | Mcpa (Ethyl Hexyl Ester)                     | Bromicide MA, Nugrex, Paragon                                                                                                | Tank and Equipment Cleaner                                   |
|       | Mcpa (Iso-Octyl Ester)                       | Broadside, Agritone LVE                                                                                                      |                                                              |
|       | Mcpa (Potassium Salt)                        | Trooper®                                                                                                                     |                                                              |
|       | 2, 4-Db                                      | Buttress®                                                                                                                    | Cloudy Ammonia followed by Tank and<br>Equipment Cleaner     |
|       | 2, 4-D (Dimethylamine And<br>Diethanolamine) | Surpass 475, Amicide 625                                                                                                     |                                                              |
|       | 2, 4-D (Dimethylamine                        | Baton®, Kamba M, Surpass 475                                                                                                 |                                                              |
|       | 2, 4-D (Ethyhexyl Ester)                     | Estercide Xtra                                                                                                               | Tank and Equipment Cleaner                                   |
|       | Pyridines                                    | Archer                                                                                                                       |                                                              |
| J     | Thiocarbamates                               | Avadex® Xtra                                                                                                                 | Small amount of Tank and<br>Equipment Cleaner or water       |
| K     | Chloroacetamides                             | Bouncer                                                                                                                      |                                                              |
| L     | Bipyridls                                    | Revolver, Nuquat 250                                                                                                         | Water                                                        |
| M     | Glyphosate                                   | Roundup, Roundup Biactive<br>Roundup CT<br>Roundup PowerMAX®,<br>Roundup Ready Herbicide with PLANTSHIELD,<br>Weedmaster Duo |                                                              |
| Q     | Triazoles                                    | Amitrole, Illico®                                                                                                            | Small amount of Tank and Water<br>Equipment Cleaner or water |
| Z     | Arylamino propionic Acids                    | Mataven 90                                                                                                                   |                                                              |

# A first rinse with cloudy ammonia will clean hard deposits in filter and lines. After flushing the tank, a second rinse with Tank and Equipment Cleaner should be used as a follow up.

Spray drift is a major concern in most agricultural areas today. The presence of sensitive areas located within close proximity to the spray target area introduces the possibility of off-target deposition. It is more important than ever that the agricultural industry demonstrates responsible chemical usage to reduce the need for severe application restrictions.

For further information on chemical application or involvement in a Spraywise training course, please contact your local Nufarm Sales Manager at [www.nufarm.com.au](http://www.nufarm.com.au).

|                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|   | <h3>Plan</h3> <ul style="list-style-type: none"> <li>Utilise tools such as <a href="http://www.spraywisedecisions.com.au">www.spraywisedecisions.com.au</a> to plan the most appropriate application windows.</li> <li>Spraying in a cotton area? Check <a href="http://www.cottonmap.com.au">www.cottonmap.com.au</a> for neighbouring fields prior to application.</li> <li>Read the product label.</li> <li>Communicate with neighbours.</li> <li>Upskill by attending a Nufarm Spraywise training course or one run by specialist application consultants such as Bill Gordon, Graham Betts, Craig Day.</li> <li>Remember the 6 P's = Perfect Planning Prevents Poor Pesticide Performance.</li> </ul>                                             |
|  | <h3>Boom Height/False Target</h3> <ul style="list-style-type: none"> <li>Boom height needs to be adjusted to the height of the false target (stubble height) or the height of the target – whichever is greater.</li> <li>Keep boom height to a minimum (ie 50cm above target/false target for 110° nozzles at 50cm nozzle spacing).</li> <li>Increasing the boom height from 50cm to 70cm may increase the amount of driftable fines up to 4 times, and a boom height increase from 50cm to 100cm multiplies them up to 8 times!!</li> </ul>                                                                                                                                                                                                          |
|  | <h3>Spray Quality</h3> <ul style="list-style-type: none"> <li>A COARSE to VERY COARSE spray quality must be used when applying 2,4-D products – EXTREMELY COARSE may be warranted if night spraying.</li> <li>Choose the nozzle producing the coarsest spray quality without compromising efficacy. Refer to Nufarm's Boom Spray Application Guide for a full range of recommended water rates and spray qualities for all Nufarm products.</li> <li>If needed, include drift-reducing adjuvants such as LI 700®, Activator® or Bonza®.</li> <li>Use nozzles at appropriate pressure: conventional nozzles 1.5-3 bar, pre-orifice nozzles 2-4 bar, Low-pressure air induction nozzles 3-5 bar, high-pressure air-induction nozzles 4-8 bar.</li> </ul> |





### Inversions

- **DANGER – DO NOT** spray when a low-level inversion exists.
- During those inversions distinct, isolated layers of air have formed close to the ground. As a result driftable fines are not subject to dilution with the atmosphere.
- Low-level inversions frequently form in the late evening and strengthen overnight - they are strongest near sunrise.
- Use visual indicators such as moisture, smoke or dust to determine if a low-level inversion is present.
- Rule of thumb: the greater the difference between daily maximum and minimum temperatures, the stronger the low-level inversion.



### Night Spraying

- The advent of GPS self-steer and a desire to work within appropriate Delta Ts has seen an increasing trend towards night spraying, particularly during the summer months. Spraying at night dramatically increases the chance of applying product in adverse conditions.
- Night spraying can strongly favour conditions that can trap and move the applied product far from the target area (see inversions). Be particularly vigilant 1 hour either side of sunrise.
- Be aware that the rainfast period will be longer.
- Obtain forecast and monitor for still or low-level inversion conditions.



### Wind Speed and No-Spray (Buffer) Zones

- It is best to apply pesticides when the wind is blowing away from sensitive areas and crops. Wind speed must be steady between 3 km/h and 15 km/h.
- If the wind stops blowing at night – stop spraying immediately (see inversions).
- Always read the label to see if a mandatory wind speed requirement exists, or if a No-spray zone is required for any of the products you plan to use.
- Rule of thumb: most directional wind changes in Australia will occur in an anti-clockwise direction.



### Spray Weather Summary

- Avoid calm, variable or gusty wind (calm conditions give no positive indication of droplet displacement).
- Be aware of local topographic and convective influences on wind speed and direction.
- At night the cool (heavier) air behaves like water and drains to lower points (waterways, frost-prone paddocks) taking any fine droplets suspended in the air with it as well.
- Record on-site weather conditions at the start and finish of every pesticide application.

\* Courtesy of 'Weather for Pesticide Spraying' Bureau of Meteorology pamphlet.  
Nufarm acknowledges input from Graham Betts, Bill Gordon and Graeme Tepper.

# Weed management

By **JAMES HILL**

Acknowledgements: Graham Charles (Industry & Investment NSW), Tracey Leven (CRDC) and Jeff Werth and David Thornby (DEEDI)

## Developing an IWM strategy for your farming system



### What is IWM?

Integrated Weed Management (IWM) is the development and implementation of a plan that is made up of a range of weed management tactics. IWM aims to manage today's weed problems in a manner that reduces the potential for weed problems in the future.

The main principle underlying IWM is preventing weeds from setting seed by:

- Knowing the weed spectrum and considering the interaction between weeds and the farming system (plan).
- Regularly examining the weed problem and the success or failure of recent practices (monitor).
- Assessing the weed management system and developing economic and sustainable solutions (evaluation).
- Implementing alternative management strategies to deal with any problems (response).

An IWM program uses a range of methods of weed control in combination, so that ALL weeds are controlled by at least one tactic in the weed management system.

## BE AWARE OF

- Use a range of weed management tactics to avoid future weed problems.
- Know your weeds.
- Know your risk of resistance considering your farming system.
- Ensure your cotton fields are identified on the Cotton Map to assist with reducing phenoxy drift.
- For further information and support when implementing your integrated weed management strategy, refer to the IPM – insect, weeds and diseases module in *myBMP*.
- Check and monitor weeds that survive a control and be vigilant in regards to monitoring for resistance.
- Decontaminating spray rigs and tanks is VERY important for RoundUp Ready Flex cotton.

In short, IWM is about NOT relying on only one or two methods of weed control alone, and in particular it does not involve relying only on herbicides.

When developing an IWM program, think strategically about how you can best utilise all available weed control methods in cotton, in rotation crops and in fallows. A short term approach to weed management may reduce costs for the immediate crop or fallow, but may not be cost effective over a five or ten year cropping plan.

Over this duration, problems with species shift and the development of herbicide resistant weed populations are likely to occur where weed control has not been part of an integrated plan. Herbicide resistant weed populations are increasingly common in NSW and Queensland.

## Why use IWM in cotton systems?

Effectively managing weeds using an integrated program for the entirety of the cropping rotation will reduce:

- rate of shift in weed spectrum towards more herbicide tolerant weeds
- risk of selecting herbicide resistant weeds and so prolong the useful life of each herbicide
- future weed control costs by reducing the number of weed seeds in the soil seed bank
- competitiveness of weeds and improve crop productivity each year.

Although all of these outcomes are important, reducing the risk of developing herbicide resistant weeds is critical. Throughout the world 185 weed species have developed resistance to different herbicides. Thirty-six weeds have developed resistance to herbicides in Australia.

In northern NSW populations of 3 common grass weeds – awnless barnyard grass, liverseed grass and annual ryegrass (also occurring in southern NSW) – have resistance to glyphosate. Weeds with resistance to multiple herbicides are also occurring more frequently.

The following tactics should be used to develop an integrated weed management strategy for your farm to help prevent the development of herbicide resistance.

## IWM tactics in cotton

### Key weeds are identified

Ensure that weeds are correctly identified before deciding upon a response. Refer to CRC Weed Identification Tool ([/www.cottoncrc.org.au/content/Industry/Publications/Weeds/WeedIdentificationTools.aspx](http://www.cottoncrc.org.au/content/Industry/Publications/Weeds/WeedIdentificationTools.aspx))

### Scouting

Scouting fields before weed control is implemented, enables the best control option to be used. Scouting should be repeated to assess efficacy post treatment.

For IWM strategies to be effective in preventing resistance, weeds that survive a herbicide must be controlled by another method before they set seed. Weeds may need to be closely examined, as some are capable of setting seed while very small.



# Prevent whiteflies from infesting your next cotton crop by controlling their alternative host plants.



Volunteer Cotton.  
4 Days after application



Peach vine.  
3 Days after application



Dwarf Amaranth.  
4 Weeks after application



Bellvine.  
4 Days after application

**PLEDGE**  
HERBICIDE  **500 WG**

For more information visit  
[www.sumitomo-chem.com.au](http://www.sumitomo-chem.com.au)



SUMITOMO CHEMICAL

Identify and closely monitor areas where machinery such as pickers and headers breakdown. Weed seeds are often inadvertently released when panels are removed from machines for repairs.

Weed scouting in non-crop areas of the farm is a valuable source of information for planning future weed management strategies.

### Field records

For all fields, maintain records of weed control methods and their effectiveness after every operation. Consider the records from past years in this year's decisions, particularly in relation to rotating herbicide modes of action. Repetitive use of the same mode of action group over time is closely associated with the evolution of herbicide resistance. In addition records are useful in terms of crop rotations and plant back periods. For symptoms of suspected herbicide damage refer to CRC website [www.cottoncrc.org.au/content/Industry/Tools/Herbicide\\_Damage\\_Identification.aspx](http://www.cottoncrc.org.au/content/Industry/Tools/Herbicide_Damage_Identification.aspx)

### The spring tickle

The spring tickle uses shallow cultivation in combination with a non-selective, knockdown herbicide. The aim of the spring tickle is to promote early and uniform germination of weeds prior to sowing to ease weed pressure in-crop. Some weed species are more responsive to the spring tickle than others. Highly responsive weeds include bellvine and annual grasses – liverseed grass and the barnyard grasses.

### Double knock

The double-knock technique is a fallow weed control tactic that is being used widely in southern states to manage hard to control weeds such as herbicide resistant annual ryegrass.

When executed well, the double-knock tactic will provide 100% control. In cotton systems there are several ways the technique can be applied to improve control of weeds such as flaxleaf fleabane and simultaneously reduce the risk of resistance developing in other key weed species such as liverseed grass and awnless barnyard grass.

More recently the double-knock has come to be the use of two herbicides. When using two herbicides, the basis of the double-knock is to apply a systemic herbicide, allow sufficient time for it to be fully translocated through the weeds, then return and apply a contact herbicide, from a different mode of action group, that will rapidly desiccate all of the above ground material, leaving the systemic product to completely kill the root system.

Most commonly glyphosate is followed with a Group L product. The optimum time between the treatments is dependent on the weed targets. Small, rapidly growing grasses respond best when the second application occurs 3–5 days after the first. When slightly larger fleabane is the target, separate the applications by 7–10 days.

### Encourage insect predation

Insect predation can contribute significantly to natural mortality in the weed seed bank. Seed theft by ants commonly causes failure of pasture establishment, so it is feasible that weed seed banks can be decreased by encouraging ants.

In Bollgard II® cotton and unsprayed refuges feeding by the Datura leaf beetle, *Lema trivittata*, can prevent thornapples from setting seed.

### Herbicide tolerant crops are grown according to licence requirements

Herbicide tolerant cottons allow the use of non-selective herbicides for summer weed control in-crop. Incorporating this tactic into the IWM strategy allows for more responsive, flexible weed management. Weeds need only be controlled if and when germinations occur, meaning herbicide application can be timed to have maximum impact on weed populations. In relatively clean fields the reliance on residual herbicides for in-crop management is reduced. In fields known to have heavy weed burdens, using the non-selective together with residual herbicides can achieve very high levels of control. Avoid using the same herbicide to control successive generations of weeds. Use the weed calculation tool to assist with timing of Roundup Ready application (see web address below) [http://www.cottoncrc.org.au/content/Industry/Tools/Agronomy\\_Tools/Field\\_Record\\_Forms.aspx](http://www.cottoncrc.org.au/content/Industry/Tools/Agronomy_Tools/Field_Record_Forms.aspx)

### Prevent weed establishment

Where cotton is grown in rotation with crops such as winter cereals or maize, retain stubble cover from these rotation crops for as long as possible. Stubble cover reduces weed establishment and encourages more rapid breakdown of weed seed on the soil surface.

### Protect yield potential

Young cotton is not a strong competitor with weeds. The critical times when weed competition can cause yield loss are provided in the Cotton Pest Management Guide for a range of weed densities and weed types. Irrespective of the type of weeds, early season control is critical to prevent yield loss. The higher the weed population, the longer into the season weed control is required.

### Control survivors and late germinations

Use a range of selective controls – inter-row cultivation, lay-by herbicide, chipping and spot spraying – to prevent seed set in weeds that survived early season tactics or have germinated late.

For a range of reasons, situations will occur when some weeds escape control by herbicides:

- Missed strips due to poor operation of equipment;
- Insufficient coverage due to high weed numbers;
- Applying the incorrect rate; and,
- Interruptions by rainfall are just a few reasons why weeds escape control.



If herbicide resistant individuals are present, they will be amongst the survivors. It is critical to the longer term success of the IWM strategy that survivors not be let to set seed.

### Inter-row cultivation

Inter-row cultivation can be used to prevent successive generation of weeds from being targeted by post-emergent herbicides. Cultivating when the soil is drying out is the most successful strategy for killing weeds and will reduce the soil damage caused by tractor compaction and soil smearing from tillage implements.

### Manual chipping

Manual chipping is ideally suited to dealing with low densities of weeds, especially those that occur within the crop row. Whilst this is an expensive option, perhaps it should be costed not just to this crop, yet also to subsequent crops.

### Spot spraying

Spot sprayers may be used as a cheaper alternative to manual chipping for controlling low densities of weeds in crop. Ideally, weeds should be sprayed with a relatively high rate of a herbicide from a different herbicide group to the herbicides previously used to ensure that all weeds are controlled.

### Crop rotations

Rotation crops enhance IWM by:

- Introducing herbicide options not available in cotton.
- Producing stubble loads that reduce subsequent weed germinations (important to remember stubble loads and their impact on emerging cotton plants).
- Varying the time of year non-selective measures can be used and the time of year that crop competition suppresses weed growth.

Rotation between summer and winter cropping provides opportunities to use cultivation and knockdown herbicides in-fallow at all times of the year.

### Bury seed of surface-germinating species

Use strategic cultivation to bury weed seeds and prevent their germination. Some weed species, such as common sowthistle (milk thistle) and flaxleaf fleabane, are only able to germinate from on or near the soil surface (top 20mm).

### Good farm hygiene is practiced

To minimise the entry of new weeds into fields, clean down boots, vehicles, and equipment between fields and between properties. Pickers and headers require special attention. Eradicate any new weeds that appear while they are still in small patches. Monitor patches frequently for new emergences.

Irrigation water can be a source of weed infestation with weed seeds being carried in the water. While it is not practical to filter seeds from the water, growers should

be on the look out for weeds that gain entry to fields via irrigation. Control weeds that establish on irrigation storages, supply channels and head ditches.

## Critical success factors in IWM

### Timely implementation of tactics

Often the timeliness of a weed control operation has the largest single impact on its effectiveness. Herbicides are far more effective on rapidly growing small weeds, and may be quite ineffective in controlling large or stressed weeds. Cultivation may be a more cost-effective option to control large or stressed weeds, but additional costs can be avoided through being prepared and implementing controls at the optimum time.

### Rotate herbicide groups

All herbicides are classified into groups based on their mode of action in killing weeds. Rotate herbicide groups whenever possible to avoid using the same group on consecutive generations of weeds. When this is unavoidable, use other methods of weed control in combination with the herbicide and ensure no weeds survive to set seed. The cotton industry is very fortunate to have registered herbicides in the majority of the mode of action groups.

### Herbicides applied according to label directions

Herbicides are a principal component of most IWM strategies so it is important that they are used in the most effective manner possible. When reading the herbicide label check;

- Rate you are about to use is right for the growth stage of the target weeds.
- Whether a wetter or crop oil is required to maximise herbicide performance.
- Application set up you are about to use is consistent with the label – water volume, droplet spectrums, operating pressure.
- For additional, specific information regarding appropriate weather conditions for spraying.

### Consider other aspects of crop agronomy

Most agronomic decisions for cotton have some impact on weed management. Decisions such as cotton planting time, pre-irrigation versus watering-up, methods of fertiliser application, stubble retention and in-crop irrigation management all have an impact on weed emergence and growth. The influence of these decisions should be considered as part of the IWM program. r herbicide resistance in cotton farming systems

## Resistance

There are currently no reported cases of herbicide resistant weeds in cotton farming systems. However the increasing use of glyphosate associated with Roundup Ready™ technologies may increase the risk of resistance developing.

The cotton growing regions are closely aligned with the northern grains region. Across this area, there are 16 weed species that have developed resistance to at least one herbicide mode of action. Most recently, liverseed grass with resistance to glyphosate has been confirmed for the first time.

Development of herbicide resistant weed populations has been most strongly associated with cropping systems where there is minimal or no use of tillage and where there is only limited rotation between summer and winter cropping. The weeds considered to be at highest risk of developing resistance in the north are barnyard grass, liverseed grass, wild oats and sow thistle. These weeds are all able to germinate and establish over a wide range of temperatures and have very high capacities for seed production, meaning more than one generation can be exposed to herbicide selection pressure each season.

It is essential that the growers follow the industry's best management practices and are proactive in preventing the development of herbicide resistance.

Refer to [www.myBMP.com.au](http://www.myBMP.com.au)

### Looking for the early signs of resistance

Herbicide resistance is normally present at very low frequencies in weed populations before the herbicide is first applied. Using the herbicide creates the selection pressure that increases the resistant individuals' likelihood of survival. The underlying frequency of resistant individuals within a population will vary greatly with weed species and herbicide mode of action.

| Self Assessment – for possible herbicide resistance: Y/N                                                                                                                                          |                                                                                                                                                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.                                                                                                                                                                                                | Was the rate of herbicide applied appropriate for the growth stage of the target weed?                                                          |
| 2.                                                                                                                                                                                                | Are you confident you were targeting a single germination of weeds?                                                                             |
| 3.                                                                                                                                                                                                | Were the weeds actively growing at the time of application?                                                                                     |
| 4.                                                                                                                                                                                                | Having referred to your spray log book, were weather conditions optimal at the time of spraying so that herbicide efficacy was not compromised? |
| 5.                                                                                                                                                                                                | Are you confident the suspect plants haven't emerged soon after the herbicide application?                                                      |
| 6.                                                                                                                                                                                                | Is the pattern of surviving plants different from what you associate with a spray application problem?                                          |
| 7.                                                                                                                                                                                                | Are the weeds that survived in distinct patches in the field?                                                                                   |
| 8.                                                                                                                                                                                                | Was the level of control generally good on the other target species that were present?                                                          |
| 9.                                                                                                                                                                                                | Has this herbicide or herbicides with the same mode of action been used in the field several times before?                                      |
| 10.                                                                                                                                                                                               | Have results with the herbicide in question for the control of the suspect plants been disappointing before?                                    |
| <b>IF you suspect herbicide resistance and require further information please refer to the Cotton Pest Management Guide, available on the Cotton CRC website or discuss with your agronomist.</b> |                                                                                                                                                 |

Resistance can begin with the survival of one plant and the seed that it produces. Early in the development of a resistant population, resistant plants are likely to occur only in small patches. This is the critical time to identify the problem. Options are much more limited if resistance is first diagnosed over large areas.

Many of the symptoms of herbicide resistance can also be explained by other causes of spray failure. Evaluate the likelihood of other possible causes of herbicide failure. Start by taking the self assessment (below). The more questions to which you have confidently answered 'Yes', the more a further investigation of possible resistance is warranted. If you have answered 'Yes' to most of these questions, including questions 8–10 on field history, take action;

- Collect samples and send for testing.
- Remove surviving plants from the field to limit the amount of seed going into the soil seed bank.
- Develop a management plan for continued monitoring of the sites and the use of alternative weed control strategies.

### Phenoxy

Cotton is extremely sensitive to phenoxy via off target application and through a poorly sterilised boom. To assist with reducing drift it is essential that you identify your cotton fields on the cottonmap website. This map will be used by spray contractors, resellers, agronomist and neighbours to identify crops.

Decontaminating spray rigs and tanks is VERY important for RoundUp Ready Flex cotton.

These guidelines are a brief version of the Integrated Weed Management Guidelines for Australian Cotton II. For more details on any of the following pages please refer to the CRC website.

#### Further information:

**WEEDpak** – <http://www.cottoncrc.org.au/content/Industry/Publications/Weeds/WEEDpak.aspx>

**Weed Identification Web Tool** – <http://www.cottoncrc.org.au/content/Industry/Publications/Weeds/WeedIdentificationTools.aspx>

**Herbicide Damage ID Web Tool** – [http://www.cottoncrc.org.au/content/Industry/Tools/Herbicide\\_Damage\\_Identification.aspx](http://www.cottoncrc.org.au/content/Industry/Tools/Herbicide_Damage_Identification.aspx)

**myBMP** – [www.mybmp.com.au](http://www.mybmp.com.au)

**Cotton Map** – <http://www.cottonmap.com.au/>



# Reducing pesticide use – saves costs

By **RHIANNON SMITH, UNE**

Acknowledgements: Nancy Shellhorne (CSIRO); Lewis Wilson, Sandra Williams, Stacey Vogel, Jane McFarlane (Cotton CRC)



Ecosystem services are the benefits that people get from the environment. Natural pest control is one of the most important ecosystem services for sustainable cotton production. Provision of this service is dictated by the populations of beneficial insects, birds, bats and other insectivorous

creatures in the landscape and their ability to move between habitats. Perennial native vegetation provides an alternative habitat for beneficials, especially when fields are in fallow thus, maintaining their population in the nearby landscape. The following principles can be used to guide native vegetation management to maximise its value for natural pest control. Managing native vegetation also enhances other ecosystem services including carbon sequestration, erosion control, nutrient cycling, water filtration and climate regulation.

## BE AWARE OF

- Beneficial insects can help reduce pesticide costs.
- Actively managing native vegetation and planting tree corridors enables beneficial insects to move through the landscape and into crops.
- Plant shrubs as well as trees. Native vegetation with many different tree, shrub and groundcover species provides the best habitat for beneficial insects.
- Minimise spray drift onto areas of native vegetation and only spray once thresholds have been reached.
- Encourage birds and bats as they can consume 50% of the pests in a crop.
- Control weeds and volunteer crop plants that act as hosts for pest species.
- Protect and enhance native vegetation by revegetating near water sources for maximum natural pest control.
- Managing native vegetation also enhances carbon sequestration, erosion control, nutrient cycling, water filtration and climate regulation.



**Many beneficial insects have limited dispersal ability. Connect isolated remnants with other remnant vegetation in the landscape to facilitate dispersal of beneficials and maximise natural pest control services.** (PHOTO: G. Roth, Roth Rural and Regional)

## Principle 1: Think beyond the crop

Think about the size and configuration of native vegetation in the region. Small, isolated remnants provide 'stepping stones' across the landscape, but the most effective natural pest control is attained from well-connected areas of native vegetation located nearby the crop. Native vegetation corridors or 'bridges' between remnants facilitate the dispersal of beneficial insects through the landscape. Where there is little remnant vegetation in an area, start a revegetation program



**Dense, complex vegetation near crops provides habitat opportunities for a range of beneficial insects and maximises natural pest control services.** (PHOTOS: Top, L. Wilson, CSIRO & bottom, CSIRO)

concentrating on creating corridors between remnants. Fence line plantings, wind breaks and roadside verges provide habitat to beneficials and allow movement between patches of remnant native vegetation.

**Tips on what species to plant for different purposes on cotton farms, and where and how to plant them can be found in the *Trees on cotton farms guide*.**

## Principle 2: Encourage beneficial insects with complex vegetation

Vegetation condition for natural pest control is best where vegetation is complex. Complex vegetation has many layers (i.e. trees, shrubs, grasses and herbs) and a range of different plant species. Complexity is achieved in pastures by incorporating a variety of different growth forms including tussocky grasses, sprawling grasses, herbs and creepers (e.g. native legumes). Further complexity is achieved by incorporating logs, dead trees and litter. When planning revegetation for natural pest control, incorporate trees and shrubs that flower prolifically, such as eucalypts and melaleucas, these attract a range of beneficial insects. The pictures on the previous page illustrate native vegetation in good condition for natural pest control.

## Principle 3: Do not disturb

Making well informed and rational pest management decisions will provide the best opportunity to reduce the overall need to spray and hence help conserve beneficial populations. This involves frequent and accurate insect sampling, correct identification of the insect and observations of predatory insects and parasitoid activity (e.g. thrips in mite colonies or syrphid or ladybird larvae in aphid colonies or brown or black immature stages in a whitefly colony). It is equally important to consider the overall health of the crop and any pest damage that the crop may have incurred. Remember that a vigorous, healthy crop can recover from a degree of early season damage with no

reduction in yield or delay in maturity. Managing pest and damage levels using industry thresholds will help avoid economic losses inflicted from pests.

In addition, growing Bollgard II® cotton varieties dramatically reduces the need to spray for *Helicoverpa* spp. and other lepidopteran pests so will assist in retaining good populations of beneficial insects in the crop.

If it is necessary to apply an insecticide, it is very important to consider the selectivity of the insecticide, its efficacy on the target pest/s and its impact on beneficial insect species. Also bear in mind whether this insecticide may flare other pests because of the effect on beneficial insects. Consider the use of biological insecticides and also the use of reduced rates of synthetic insecticides mixed with either salt or spray oils (in some instances) to provide greater selectivity and better efficacy.

**Sampling techniques, industry pest and plant damage thresholds and insecticide impact tables are updated annually in the *Cotton Pest Management Guide*.**

## Principle 4: Consider birds and bats as beneficials

Birds and bats alone can eat more than half the insects in a cotton crop. Both birds and bats live in a variety of different habitat types, including farmlands, pastures, wetlands and woodlands, but many forage over crops. By



**Remember that native vegetation provides an excellent habitat for many beneficial insect species so it is important not to use these areas as spray drift buffer zones. This also applies to areas of remnant vegetation on neighbouring properties. (PHOTO: J. Wark, CSD Toowoomba)**



**Microbats and birds provide a valuable pest control service. Bat boxes provide a place for microbats to roost through the day where other habitats are unavailable. (PHOTOS: Top, P. Spark, Northwest Ecological Services & bottom, G. Roth, Roth Rural and Regional)**



incorporating different types of habitat on farm, a diverse range of beneficials will be available to provide natural pest control services. Revegetation complements areas of native vegetation and can be improved through the installation of bat boxes where mature trees are scarce. To minimise impacts on birds and bats, be aware that they are most active and vulnerable at dawn and dusk.

### Principle 5: Control weeds in and around the farm

Many cotton pests use volunteer cotton plants and weeds as alternate hosts prior to migrating into cotton fields. Such weeds include marshmallow (*Malva parviflora*), clovers and medics (*Trifolium* and *Medicago* spp.), capeweed (*Arctotheca calendula*), nightshade (*Solanum* spp.), bladder ketmia (*Hibiscus trionum*), thornapples (*Datura* spp.), Paddy melon (*Cucumis myriocarpus*) and cobbler's peg (*Bidens* spp.). It is therefore important to control weeds and volunteers in native vegetation, especially those actively growing prior to and at the time of cotton planting. However, it is necessary to remember that some native vegetation is sensitive to chemicals, so alternative weed control measures such as chipping may be necessary.

### Principle 6: Consider water availability

More invertebrates inhabit vegetation located near a water source as water increases and stabilises vegetation condition, especially during drought. This applies to both revegetation and remnant vegetation. Revegetation positioned near water sources, e.g. channels, storages, head and tail ditches or table drains along road sides is highly valuable for natural pest control. Riparian vegetation is also highly valuable habitat for many beneficials. Floodplain woodlands such as those dominated by river red gum, coolibah and black box rely on floodwater to persist and remain in good condition in semi-arid environments. Allow floodwaters to reach these woodland communities to maintain healthy vegetation and to maximise natural pest control potential.

For more information

'2011 Cotton Pest and Beneficial Insect Identification Guide' (released August 2011).

The Cotton CRC: <http://www.cottoncrc.org.au/content/Catchments/Home.aspx>

'Growing Trees on Cotton Farms: A Guide to Assist Cotton Farmers to Decide How, When, Where and Why to Plant Trees' – available from CRDC, Narrabri.

'Managing Riparian Lands in the Cotton Industry' – available from CRDC, Narrabri.

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# Insect & mite management

By **SALLY CEENEY & JAMES HILL**

Acknowledgements: Lewis Wilson and Sandra Williams (CSIRO), Robert Mensah and Annie Johnson (Industry & Investment NSW).



Sally Ceeney.



James Hill.

## What is integrated pest management (IPM)?

IPM involves using all means of managing pest populations with the aim of reducing insecticide use whilst maintaining profitability (yield, fibre quality and crop maturity). IPM is a whole year approach to managing pests.

## Why do we need to develop IPM programs?

Over-reliance on synthetic insecticides creates problems, such as insecticide resistance of the major pests (particularly *H. armigera*), disruption of natural enemies of the pests leading to outbreaks of secondary pests such as mites, aphids or whitefly and other environmental consequences. These problems have cast doubt over the long-term viability of the traditional insecticide dominated approach to pest management.

### BE AWARE OF

- Integrated Pest Management (IPM) aims to reduce insecticide use but maintain profitability.
- IPM is a whole year approach to managing pests.
- Adhering to your IRMS strategy is one way to help manage insecticide resistance.
- Over reliance on synthetic insecticides can lead to:
  - Insecticide resistance;
  - Disruption of natural pest enemies;
  - Outbreaks of secondary pests;
  - Environmental consequences; and,
  - Increased economic costs in controlling pests.
- For further information and support in carrying out integrated insect and mite management refer to the IPM module in *myBMP*.

A major goal for the cotton industry is to reduce dependence on foliar and soil applied insecticides. This can be achieved by developing an IPM program that integrates a range of pro-active management tactics, especially the conservation and use of natural enemies (predators and parasites) to control pests.

## How do we implement IPM?

IPM involves integrating a range of tools and strategies for managing pests. These can be conveniently grouped in seven main objectives:

- Growing a healthy crop;
- Keeping track of insects and damage;
- Preserving beneficial insects;
- Preventing insecticide resistance;
- Managing crop and weed hosts;
- Using trap crops effectively; and,
- Communication.

## Growing a healthy crop

This objective covers the key issues for good crop agronomy and highlights how they interact with IPM.

Growing a healthy cotton crop optimises both its yield potential and capacity to compensate for pest damage.

### Field selection

When selecting fields for planting cotton consider proximity to sensitive areas such as watercourses, pastures, buildings, and the prevailing wind direction. Bollgard II® varieties may be appropriate for fields near sensitive areas. Another consideration would be the proximity of these cotton fields to other crops or orchards which can potentially act as a source for secondary pests such as mites, aphids or whitefly.

### Seed bed preparation

A tactic often mentioned by cotton growers in achieving an early crop is a good seed-bed which helps achieve vigorous, healthy, early growth that tolerates seedling disease better and achieves early crop maturity and high yield potential.

### Selecting a variety

The cotton varieties planted should be matched to the region and likely pests and diseases (see CSD variety guides or websites). Select a variety that suits the growing region in terms of length of season. Shorter season varieties may also be considered as the shorter growing period reduces the time the crop needs to be protected from pest damage.

Bollgard II® cotton is ideally suited to IPM as the level of control of *Helicoverpa* spp. provided by the plant is usually sufficient to dramatically reduce the need to spray for this pest or other lepidopteran pests such as tipworm, especially early season.





## Knock them out with powerful PEGASUS® without the knock on effect

Knock out whitefly, aphids, mites and everything else and you could end up with a domino effect. 'Take out' the beneficial insects and another pest problem flares up.

Thankfully, there is a more selective solution. PEGASUS®, the only *Thiourea group insecticide* used in cotton, has excellent translaminar, contact and vapour activity. It knocks down feeding pests hard, yet because of its unique chemistry, is very soft on beneficial species.

PEGASUS also has a short 14 day withholding period, letting you use it up until the end of the season. This makes PEGASUS the perfect partner in your IPM resistance management program. For more information please call the Syngenta Technical Product Advice Line on 1800 067 108 or visit [www.syngenta.com.au](http://www.syngenta.com.au).

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## Planting window

In each cotton region there is a period when soil temperatures become suitable for cotton germination, 14°C minimum at planting depth. Planting at this time usually maximises plant establishment and avoids the risk of cold shock (night temperature < 12°C). Cold shock slows early growth and reduces tolerance to herbicides, seedling diseases and early pests, especially thrips. Very late planted cotton has less yield potential and is more susceptible to pests such as whitefly and late season infestations of *H. armigera* both of which are difficult and expensive to control.

In areas susceptible to whitefly, coordinated planting windows can provide a period free from host crops to reduce population build up as well as preventing late crops. The 42 day planting window for Bollgard II® cotton is a critical component of the resistance management plan.

## Optimising water and nitrogen

Adequate water and nutrition will ensure healthy growth of plants that are more tolerant of pests and diseases. Too much nitrogen creates excessive cotton growth toward the end of the season and perhaps even the need for an extra irrigation. This makes the crop more attractive to pests, requiring additional inputs of insecticides (and mixtures of insecticides) for control, and application of high rates of growth regulators to retard growth.

## Growth regulators

Excessive vegetative growth is a problem because it reduces the retention of fruit and delays maturity. Rank growth of plants also results in reduced efficacy of insecticides due to poor penetration of the canopy.

The CottASSIST Cotton Development Tool can calculate vegetative growth rates to determine crop needs. ([www.CottASSIST.cottoncra.org.au](http://www.CottASSIST.cottoncra.org.au))

## Final irrigation

The timing of the last irrigation aims to ensure that boll maturity is completed without water stress, and at the same time prevent the occurrence of lush crop being attractive to the *Helicoverpa* spp. and other pests such as aphids and whitefly.

## Defoliation

The timing of defoliation can be an important IPM tool, as late pest infestation problems can sometimes be overcome by a successful defoliation.

## Keeping track of pest and beneficial abundance and plant damage

The purpose of crop monitoring is to determine:

- The pest(s) present;
- The level of infestation;
- The damage they are causing;
- The level of beneficial insects;



**Crop scouting.**

- Expected response to control options;
- Environmental conditions; and,
- The growth stage of the crop.

This information provides the basis on which pest management decisions are made.

## Check frequently

Crops should be checked frequently (at least twice weekly) for pests, beneficials and for damage and fruit retention.

## Types of sampling techniques

**Visual sampling:** This involves looking at the entire plant, including under leaves, along stems, in squares and around bolls.

**Beat sheet sampling:** A sheet of yellow canvas 1.5 m × 2 m in size is placed in the furrow and extended up and over the adjacent row of cotton. A metre stick is used to beat the plants 10 times against the beat sheet, moving from the base to the tops of the plants. Insects are dislodged from the plants onto the canvas and are quickly recorded.

**D-Vac sampling:** Can be used as an alternative to visual for sampling spiders and beneficial insects. A sweep net may be an alternative to the beat sheet when the field is wet. A D-vac is also effective in Refuge crops such as Lucerne to sample beneficial numbers.

It is generally not possible to make a decision about whether control is needed based on just one check. The decision making system needs to be flexible to allow for the action of beneficials and natural mortality..

Insect numbers should be recorded either as numbers per metre or as a percentage of plants infested to easily compare numbers with the appropriate industry threshold and to allow a predator to prey or pest ratio to be determined.



### How much to sample

This will vary according to growth stage and individual factors. It is also vital to consider plant damage, fruit load, yield and maturity.

Damage monitoring includes:

- Leaf loss (up to the 6 true leaf growth stage);
- Tip damage;
- Fruit retention or fruiting factor; and,
- Boll damage.

### Crop Development Tool (CDT)

Cotton development can be predicted using daily temperature data (day degrees). The Crop Development Tool (CDT) uses this knowledge to enable crop managers to check the vegetative and reproductive growth of their cotton crops compared to a potential rate of growth and development. A crop manager can use this information as a prompt to further explore why the crop may not be on track, and manage the crop accordingly. To use the CDT, access CottASSIST through the Cotton CRC website; [www.CottASSIST.cottoncrc.org.au](http://www.CottASSIST.cottoncrc.org.au)

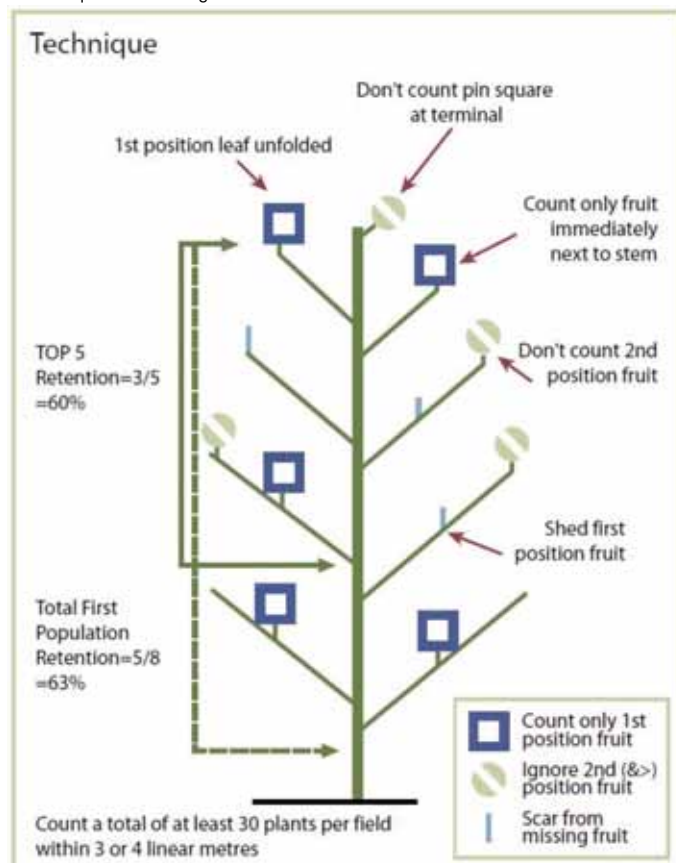
### First position fruit retention

Monitoring first position fruit retention is a technique that is best used from squaring to early flowering. It is a quick way to estimate early signs of insect damage (Refer to figure 1).

- Count the first position fruit on either the top five or all the fruiting branches.

**FIGURE 1.**

A technique for checking fruit retention.



- Monitor both tipped and non-tipped plants.
- Monitor only the dominant stem, not vegetative branches.

Aim to have first position fruit retention of 50–60% by first flower. Low retention (< 50%) increases the risk that yield or crop maturity will be affected. However, very high fruit retention, in excess of 80% may also be associated with a yield penalty.

### Preserving beneficial insects

Predatory insects, spiders and parasitic insects (beneficials) consume pests. Beneficials can considerably reduce pest numbers thereby reducing the need to control pests using chemical insecticides. The abundance of beneficial insects is affected by food resources, mating partners, over wintering sites, shelter, climatic conditions and insecticide sprays. For an IPM system to work, the conservation of beneficial insects is critical. This can be achieved through the use or provision of natural or crop refuges (e.g. trees, pastures or lucerne strips).

In an IPM system which focuses on managing beneficials the following tools can be used;

- Predator / Pest ratio;
- Incorporating parasitoids into spray decisions;
- Beneficial releases;
- Food sprays;
- Lucerne strips;
- Appropriate use of pesticides;
- Beneficial Disruption Index; and,
- Petroleum spray oils (PSO) mixed with a selective or biological pesticide.

### Appropriate use of insecticides

- Minimising early season sprays helps to conserve the beneficial insect population. The cotton plant has the ability to tolerate a level of damage without affecting yield or crop maturity.
- Many beneficial species frequently move in and out of cotton, other crops and non-crop habitats. It is important to manage pests on a field by field basis or by a small management unit, not an entire farm.
- Pests such as aphids or mites often infest the edge of a field, not the entire field area. It is possible to manage this type of infestation by only spraying the field borders. This enables the beneficial population to re-establish or re-build much faster.
- Some insecticides have very little impact on beneficial insects including parasitoids.

### Follow the Insecticide Resistance Monitoring Strategy (IRMS) when selecting pest control options

Resistance occurs when application of insecticides removes susceptible insects from a population leaving those individuals that are resistant. Mating between these

resistant individuals gradually increases the proportion of resistance in the pest population as a whole. Eventually this can render an insecticide ineffective, leading to field control failures. Resistance can be due to a trait that is already present in a small portion of the pest population or due to a mutation that provides resistance.

Management of resistance is essential to ensure that valuable insecticides remain effective. The Australian cotton industry has developed the Insecticide Resistance Management Strategy (IRMS). The IRMS is designed to prevent resistance development, while managing existing resistance. Some core principles used in the IRMS include:

- Rotation between chemical groups with different modes of action.
- Limiting the time period during which an insecticide can be used. This restricts the number of generations of a pest that can be selected in each season.
- Limiting the number of applications, thereby restricting the number of selection events.

See the Cotton Pest Management Guide for the 2010/2011 IRMS.

### Resistance monitoring

Resistance monitoring for *Helicoverpa* spp., two-spotted spider mites, aphids and silverleaf whitefly, is conducted each year by the cotton industry and provides the foundation for annual review and updating of the IRMS. All growers and consultants have access to this industry service to investigate suspected cases of resistance.

### Pupae busting

In NSW and southern Queensland, *Helicoverpa* spp. overwinter in the soil as pupae and emerge as moths in spring to mate and lay eggs. Known as diapause, this resting pupal state is induced by decreasing daylength and temperature in late summer. Most of the pupae which over-winter in cotton fields are *H. armigera*. They are likely to have a high survival rate because of the low numbers of parasites. They have the potential to carry insecticide resistance, including Bt resistance, through to the next season. Therefore, it is important to pupae bust for their control.

Pupae are likely to be found in the top 10cm of the soil surface. Cultivate to achieve disturbance of the soil sufficiently to destroy pupae or their emergence tunnels. The tillage required for:

- 1 m hills – till the whole hill;
- 2 m beds – till across the whole bed and almost down to furrow level;
- Skip-row – till right across the soil surface.

Pupae busting Bollgard II® cotton fields is mandatory between picking and the end of July.

### Web tool to assist pupae busting decisions

The proportion of pupae entering diapause increases from low levels in March to high levels, almost 100%, by late April. However the rate of diapause induction varies

from season to season and region to region. Knowing when diapause is induced is useful for identifying 'high risk' fields, i.e. those fields most likely to have diapausing pupae that should be targeted for pupae busting. On the Cotton CRC website, a web tool is available to help calculate the likely rate of diapause induction for your area, based on local climate data. The tool is also able to compare the results for the current season with the long term average and hotter than average or cooler than average seasons.

The web tool can also be used to predict the rate of moth emergence from diapause in spring. This can assist in timing pupae busting operations to maximise their effectiveness. The breaking of diapause is influenced by temperature. The tool calculates the emergence percentage from the day after the threshold temperature of 18°C is reached. To use the tool go to: <http://CottASSIST.cottoncrc.org.au/DIET/DIETTool.aspx>

### Trap crops and weed control

Trap cropping and weed control assists resistance management, as well as IPM, by reducing the size of the overall pest population which reduces the need to apply insecticides and reduces the selection pressure for the pest to develop resistance.

### Resistance management for Bollgard II® cotton

Resistance management for Bollgard II® cotton is critical due to the season long selection of *Helicoverpa* spp. to the Bt toxins produced by Bollgard II®. A proactive Resistance Management Plan (RMP) has been developed to preserve the effective life of Bollgard II®.

### Resistance management guidelines for all crops

Several other strategies that are relevant to cotton and other spring and summer crops can also help in managing resistance. These include:

- Avoid cross selection for resistance. Spraying for one pest can be simultaneously selecting resistance in another pest that is present, even though that pest is at sub-threshold levels and not specifically being targeted. For example, if a pyrethroid is used to control a pest other than *Helicoverpa* spp. Do not follow up with another pyrethroid for *H. armigera* control as the first spray may have already selected for pyrethroid resistant *H. armigera*. This applies to all insecticides which target multiple pest species.
- Selective insecticide use is preferable, consistent with the IRMS, as this helps conserve beneficial insects. Beneficials eat or parasitise resistant as well as susceptible pests.
- Ensure spray applications are accurate, timely and triggered by pest thresholds. Using plant compensation allows for the plant's capacity to recover from a degree of damage without loss, thereby avoiding insecticide applications to prevent non-economic damage.



## Managing weeds and crop residues

### Weed management

The potential for pests to over-winter on weeds, and infest the subsequent cotton crop early in the season, is often greatest when a mild wet winter occurs. Ideally, management of weeds, in fallow fields, cropped fields, and in the borders and headlands should be undertaken early in winter and continue through winter and spring as necessary.

Weeds provide over winter hosts for a number of pests including mites, whitefly, mirids, aphids, tipworm, cutworm and armyworm. Growing of refuge crops for beneficials, such as Lucerne, is an option available to growers who want to enhance beneficial numbers.

### Managing cotton regrowth

Regrowth of cotton after harvest (ratoon cotton) provides refuge for *Helicoverpa* spp., spider mites, green mirids, apple dimpling bugs and aphids. Regrowth should be controlled by slashing, root pulling and/or mulching to prevent pests being carried between seasons.

Regrowth cotton is also a risk for carry-over of the disease Cotton Bunchy Top (CBT). Cotton aphids feeding on these plants could then pick up CBT and spread it to adjacent cotton crops in the following season. Cotton regrowth also has implications for managing soil-borne diseases (see the Integrated Disease Management guidelines).

Technology Users Agreements for GM cottons require the control of cotton regrowth. For more information on the requirements for managing Bollgard II® volunteers see the Cotton Pest Management Guide.

### Rotation crops

Growing a range of crops can be seen as essential to providing a habitat for a variety of insects. Cotton

in monoculture over a wide area provides a little opportunity for beneficials to thrive and persist.

The selection of a rotation crop has many implications for pest management. Rotation crops are hosts for a range of pests, such as mites (faba beans, safflower), aphids (faba beans, canola) or *H. punctigera* (chickpeas, canola). Some rotation crops may also affect carry over of disease or conversely provide a disease break as suggested in Integrated Disease Management Guidelines.

Options for managing pests in rotation crops should also be considered. With no major initiative to structure insecticide resistance management in field crops other than cotton, follow the basic IPM principle to use as many methods as possible to manage pests.

Further information on rotation crops can be found in the Crop Rotations chapter.

## Use trap crops effectively

Trap cropping is an IPM tactic that can be utilised on a farm level or area wide basis. Trap cropping aims to concentrate a pest population into a manageable area by providing the pest with an area of preferred host crop. When strategically planned and managed, trap crops can be utilised at different times throughout the year to help manage a range of pests. This assists resistance management as well as IPM, by reducing the size of the overall population which reduces the need to apply insecticides and reduces the selection pressure for the pest to develop resistance.

### First generation or spring trap cropping

Spring trap crops are designed to attract *H. armigera* adults as they emerge from over wintering pupae in spring. Larvae arising from eggs laid in the crop are controlled using a biological insecticide or allowed to pupate and are controlled by cultivation. A trap crop, strategically timed to flower as pupae are emerging in spring combined with effective pupae busting in previous autumn can help to reduce the early season build-up of *H. armigera* in a district.

An ideal first generation trap crop is one that is; very attractive to *H. armigera*, is a good nursery for beneficials, does not host secondary pests or diseases, does not become a weed problem and is easy to establish and manage. Many winter crops have been trialled to measure their potential as a spring trap crop. Chickpea has consistently proven superior to all other crops in its ability to generate large numbers of *H. armigera*, however it is not a good nursery for beneficial insects. Chickpea has also proven to be agronomically robust, being suitable for both dryland and irrigated situations.

Growers must ensure trap crops do not become future nurseries of *Helicoverpa* spp., and so effectively controlling populations in the trap crop by timely destruction of the crop itself is required. Because the trap crop will not be harvested for yield, a fast knock-down insecticide is not required. Bio-pesticides like Bt and virus formulations may be well suited.



Faba beans.

### Summer trap cropping

A summer trap crop aims to draw *Helicoverpa* spp. away from the main crop and concentrate them in a small area planted to another crop such as sorghum. Once concentrated into the trap crop, the larvae can be controlled.

Some summer trap crops may produce large numbers of beneficial insects that can then move into nearby crops, for example, the *Trichogramma* spp. in sorghum and maize.

The trap crop would be planted mid season, to ensure that it was highly attractive to *H. armigera* late in the cotton season. The attractiveness of the cotton crop relative to the trap crop may significantly influence the potential effectiveness of this strategy.

In Central Queensland cotton growers are using summer trap crops of pigeon pea as part of the RMP for Bollgard II® cotton.

### Communication

Communication with neighbours, farm workers, the consultant and the applicator is essential to develop a successful IPM program.

### Pesticide Application Management Plan (PAMP)

The core best management practice for safe and responsible pesticide use is to develop a pesticide application management plan (PAMP). The PAMP will help ensure that everyone involved in a pesticide application has a clear understanding of their responsibilities. It also helps identify the risks associated with pesticide applications so that controls to minimise those risks can be put in place.

A PAMP has two essential aims:

1. Establishing good communication with all involved in the application of pesticides. This communication is required both pre-season and during the season. It should exist between the grower, the applicator, the consultant, farm workers and neighbours.
2. Ensuring appropriate application techniques and procedures are used.

Supporting these aims is good record keeping – of each aspect of the PAMP itself, and the details of pesticide application. This record keeping is important to check the effectiveness pesticide applications, to comply with regulatory requirements and to demonstrate due diligence.

For more information and assistance in developing a PAMP refer to the Pesticide Management module in *myBMP*.

### Area Wide Management (AWM)

AWM groups or IPM groups acknowledge that pest and beneficial insects are mobile, and that the management regimes to control pests imposed on a given field are likely to alter the abundance of beneficial insects and levels of insecticide resistance in pest populations in the surrounding locality. By communicating and

coordinating strategies, AWM groups have successfully implemented IPM.

### AWM for population management

AWM in the true sense primarily strives to reduce pest pressure by co-ordinating the efforts of growers in an area. The strategy is based on reducing the survival of over wintering, insecticide-resistant *H. armigera* pupae, reducing the early season build-up of *H. armigera* on a regional/district scale, and to reduce the mid-season population pressure on *Helicoverpa*-susceptible crops. The main tactics are spring trap crops, conservation of beneficial insects and cultivation of diapausing pupae. A critical component is to bring together farmers from a range of different enterprises, including cotton and other dryland crops. As *H. armigera* is a pest common to most of these crops it is vital to have all types of growers involved if AWM is to succeed.

### AWM or IPM groups

These groups focus on communication and co-ordination to achieve agreed IPM goals. These may include conserving beneficials, delaying use of disruptive insecticides, reducing the risk of drift between farms and the planting of trap crops. A key element of most groups that have worked well has been regular meetings before and during the season to share information, discuss strategies and build rapport.

These guidelines are a brief version of the Integrated Pest Management Guidelines for Australian Cotton II.

Further information:

IPM Guidelines for Cotton Production Systems in Australia - [http://www.cottoncra.org.au/content/Industry/Publications/Pests\\_and\\_Beneficials/Integrated\\_Pest\\_Management\\_Guidelines.aspx](http://www.cottoncra.org.au/content/Industry/Publications/Pests_and_Beneficials/Integrated_Pest_Management_Guidelines.aspx)

Cotton Pest Management Guide – <http://www.dpi.nsw.gov.au/agriculture/field/field-crops/fibres/cotton/cotton-pest-management-guide>



# Disease management

By **SUSAN MAAS**

Acknowledgements: Stephen Allen (CSD), Linda Smith, Linda Scheikowski, Cherie Gambley and Murray Sharman (DEEDI)

## Developing an Integrated Disease Management (IDM) strategy for your farm



Effective disease management must be integrated with management of the whole farm. Basic strategies should be implemented regardless of whether or not a significant disease problem is evident. These basic strategies should focus on the host, the pathogen and the environment.

### Host

A particular plant may be immune, resistant or susceptible. Breeders also use the term 'tolerance' to imply good performance (yield) despite the presence of the disease.

#### 1. Plant resistant varieties

- Level of resistance to Verticillium wilt indicated by a higher V.rank.
- Levels of resistance to Fusarium wilt indicated by a higher F.rank.
- Consider seedling vigour of variety particularly when watering up or planting early. Refer to CSD variety notes for more information.
- When the Black root rot pathogen is present, use more indeterminate varieties that have the capacity to catch up later in the season.
- For back to back fields, disease risks can be higher increasing the value of planting resistant varieties and late planting.

### BE AWARE OF

- Control volunteer and ratoon cotton throughout the year.
- Ensure vehicles, equipment and people have followed Come Clean Go Clean.
- Where pathogens are known to be present, plant resistant varieties as late as possible in the window.
- Monitor crops throughout the season for diseases.
- Manage crop residues and consider crop rotations based on best practice for diseases present in field.
- Utilise industry pathology services where unusual symptoms or new diseases are present.

- Bacterial blight is endemic in all cotton areas. All commercial varieties offer robust resistance to current strains of bacterial blight.

#### 2. Grow a healthy crop

- A healthy crop is more able to express its natural resistance to disease.
- Adopt a balanced approach to crop nutrition, especially with nitrogen and potassium. Both deficiencies and excesses provide better conditions for the development of diseases such as Verticillium and Alternaria.
- Excess nitrogen greatly increases the risk of boll rot particularly in fully irrigated situations.

#### 3. Replanting

Replanting decisions should be made on the basis of stand losses, not on the size of the seedlings. For more information refer to Chapter 7c.

### Pathogen

A pathogen must be present in the area, capable of surviving the inter-crop period and adapted for effective dispersal between host plants if a disease is to occur.

#### 4. Conduct your own field disease survey

- Know what diseases are present and where they are present by conducting a disease survey in November and February of each season. Monitor and record to see if diseases are increasing. Refer to *myBMP* for a template to assist with conducting a disease survey.
- If a suspect cotton plant/s is located, submit suspect samples and healthy comparison plant samples to a plant pathologist for diagnosis/confirmation. Refer to the Cotton Pest Management Guide for information.
- Train farm staff to recognise cotton plant diseases. 'Symptoms of diseases and disorders of cotton in Australia' is a useful reference to keep in the ute or go to the Cotton CRC website for symptoms tool.



Boll rot. (Stephen Allen, CSD)



**Fusarium wilt.** (Linda Smith, DEEDI)

### 5. Good farm hygiene is practiced

- Encourage all staff and visitors to 'Come Clean-Go Clean'.
- Minimise the risk of moving diseases onto or off your farm or from one field to another by considering machinery movements within the farm and having a strategy for ensuring clean movement of machinery onto and around the farm.

### 6. Crop residues are managed to minimise carryover of pathogens into subsequent crops

- The pathogens that cause Verticillium wilt, Fusarium wilt, Black root rot, boll rots, seedling disease and Alternaria leaf spot can all survive in association with cotton and some rotation crop residues.
- Manage crop residues to minimise carryover of pathogens into subsequent crops. Incorporate cotton crop residues as soon as possible after harvest, except where Fusarium wilt is present.
- Where Fusarium is present residues should be slashed and retained on the surface for at least one month prior to incorporation.



**Verticillium wilt.** (Stephen Allen, CSD)



**Alternaria leaf spot.** (Chris Anderson, I&I NSW)

- The Fusarium wilt pathogen can also survive and multiply on the residues of non-host crops such as cereals. Currently recommendations are that residues should be buried or baled as soon as possible after harvest.

### 7. Crop rotations are utilised to assist in disease management

- Use rotation crops that are not hosts for the pathogens present. The Verticillium wilt pathogen has a large host range and most legume crops are hosts of the Black root rot pathogen. Legumes such as mungbeans and fababeans also increase the Fusarium wilt pathogen.
- The Rotation Crop Comparison Tool can assist with developing a rotation strategy.

### 8. Control alternative hosts and volunteers

- The pathogens that cause Verticillium wilt, Fusarium wilt, Black root rot, Tobacco Streak Virus and Alternaria leaf spot can also infect common weeds found in cotton growing areas. Control alternative hosts to prevent



**Tobacco streak virus.** (Murray Sharman, DEEDI)





**Cotton bunchy top.** (Stephen Allen, CSD)

build up of inoculum and carry over of disease from one season to the next.

- Cotton volunteers and cotton ratoons significantly increase the risk of diseases such as Cotton Bunchy Top carrying over between seasons.

## 9. Application of fungicides

- Fungicides are not a major component of disease management in Australian cotton.
- Where appropriate use seed treatments for seedling disease control and foliar sprays for the control of *Alternaria* leaf spot on Pima cotton.
- While Bion is not a fungicide it has been shown to improve seedling survival where *Fusarium* is present.

## 10. Biofumigation

- In addition to fixing substantial quantities of nitrogen, vetch has a biofumigation effect against Black root rot.

## 11. Control of insect vectors

- Diseases caused by a virus or phytoplasma can often be prevented by controlling the vector that carries the pathogen.
- Cotton Bunchy Top (CBT) can be transmitted by aphids feeding on infected plants then migrating to healthy plants. Transmission of Tobacco Streak Virus (TSV) to plants relies on the virus from infected pollen entering plant cells through the feeding injury caused by thrips.
- Viruses can only survive in living plants. Control of cotton ratoons and volunteers throughout winter will reduce pathogen levels and also lowers vector insect populations, drastically reducing disease risk

## Environment

Pathogens have optimum environmental requirements for infection to occur and for the disease to spread and multiply in the host plant. It may appear difficult to manipulate the environment but it can be achieved by altering row or plant spacing, irrigation method or frequency or by changing the sowing date.

## 12. Preparing optimal seed bed conditions

- Plant into well prepared, firm, high beds to optimise stand establishment and seedling vigour.
- Carefully position fertiliser and herbicides in the bed to prevent damage to the roots.
- Fields should have good drainage and not allow water to back-up and inundate plants.
- Tail water should also be managed to minimise the risk of disease spread.

## 13. Irrigation scheduling

- Applying water prior to planting provides better conditions for seedling emergence than watering after planting.
- Watch for signs of water stress early in the season if the root system has been weakened by disease (eg. Black root rot) and irrigate accordingly.
- Avoid waterlogging at all times, but especially late in the season when temperatures have cooled.
- Irrigations late in the season can result in a higher incidence of *Verticillium* wilt.

## 14. Agronomic management

- High planting rates can compensate for seedling mortality however a dense canopy favours development of bacterial blight, *Alternaria* leaf spot and boll rots. Avoid rank growth and a dense canopy with optimised nitrogen and water and with the use of growth regulators where required
- Manage irrigations, nutrition and insects for early maturity as many pathogens are favoured by cool conditions at the end of the season.
- Balanced crop nutrition is provided to assist the plants' natural resistance to disease.
- In fields where *Fusarium* wilt is present avoid inter row cultivations after seedling stage as mechanical damage to the roots provide a site for infection by the pathogen.

## 15. Sowing date

- Delay sowing as late as possible within the planting window to avoid cool, wet conditions that favour disease. Sowing when the soil temperature is above 20°C would be best for reducing cotton's susceptibility to disease, but generally this is not practical. Time planting to coincide with soil temperatures of at least 16°C and rising.

## 16. Soil health

- Cotton is highly VAM dependent. Bare fallow for more than one season or removal of top-soil (especially more

than 40cm) may result in a severe lack of mycorrhiza (VAM deficient); a cereal or green-manure crop may restore sufficient mycorrhizal fungi for cotton. Refer to the cotton rotation poster for more information.

## Farm hygiene

Farm hygiene strategies are important in controlling the spread of diseases. This is particularly important where fusarium wilt and black root rot diseases are present in fields.

Good farm hygiene measures include:

- Ensuring machinery and vehicles that enter or leave the farm are free of dirt or crop debris.
- Keeping irrigation tail-water and run-off water on the farm.
- Controlling weeds and cotton volunteers within and around fields.
- Using a crop rotation strategy.
- Maintaining good soil nutrition levels.
- Minimising spillage and loss when transporting modules, hulls, cotton seed or gin trash.

## KEY TO DISEASES AND DISORDERS OF SEEDLING COTTON

Choose your most obvious symptom from the column on the LEFT or RIGHT possible causes can be found in the centre column.

| Symptoms                                              | Disease or Disorder                                                                                                                                                                                              | Symptoms                                                                      |
|-------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| ><br>><br>Seedlings not emerging<br>><br>>            | Soil too cold<br>Soil crusting<br>Sowing depth<br><br>Rhizoctonia<br>Pithium<br><br>Wire worm<br>Fusarium wilt<br>Herbicide<br>Fertiliser burn<br>Soil compaction<br>Wind damage<br>Lightning<br>Bean root aphid | <<br><<br><br><<br><<br>Seedlings dead or dying<br><<br><<br><<br><<br><<br>< |
| ><br>Spots or dead areas on leaves<br>>               | Alternaria leaf spot<br>Bacterial blight<br>Herbicide<br>Wind damage<br><br>Thrip                                                                                                                                | <<br><<br>Leaves discoloured or distorted<br><<br><                           |
| ><br>><br>Seedlings stunted without obvious<br>><br>> | Mycorrhiza<br>Herbicide<br><br>Bacterial stunt<br>Black root rot<br>Mycorrhiza<br>Soil compaction<br>Bean root aphid                                                                                             | <<br><                                                                        |

## In season disease trouble shooting

### Early season

- Compare number of plants established per metre with number of seeds planted per metre. Refer to section 7C for further information about crop establishment and replanting decisions.
- Walk the field and look for plants that show signs of poor vigour or unusual symptoms.
- Examine seedling roots.

### During and late in season

- Walk field and look for plants that are dead, show signs of poor vigour or have unusual symptoms.
- Cut stems and examine for discoloration.

Where disease is detected in new fields, or if unsure about diagnosis, send samples of both the affected and unaffected plants to:

Cotton Pathologist  
Ecosciences Precinct,  
Basement 3 Loading Dock, Off Joe Baker Street,  
Dutton Park Qld 4102

For more information:

Cotton Pest Management Guide

Integrated disease management manual

([www.cottoncrc.org.au](http://www.cottoncrc.org.au)) or Contact Susan Maas 0749837403

myBMP has more information on good farm hygiene including appropriate come clean go clean protocols and resources to help implement a comprehensive farm biosecurity plan.

Rotation Crop Comparison Tool, Cotton CRC website.

Booklet available from CRDC Phone 02 6792 4088.

## COTTON PLANTS

Choose your most obvious symptom from the column on the LEFT or RIGHT possible causes can be found in the centre column.

| Symptoms                                                                                      | Disease or Disorder                                                                                                                                                               | Symptoms                                                                   |
|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| ><br>Plants completely dead<br>>                                                              | Fusarium wilt<br>Sudden wilt<br>Lightning<br>Cultivation                                                                                                                          | <<br><<br><<br>Plants defoliating or wilting                               |
| ><br>><br>><br>><br>Leaves with discoloured spots or dead areas and spots<br>><br>><br>><br>> | Verticillium wilt<br>Sunscald<br>Mites<br><br>Bacterial blight<br>Tropical rust<br>Nutrition<br>Wind damage<br>Chimera<br><br>Alternaria leaf spot<br>Bunchy top<br><br>Herbicide | <<br><<br><<br><br><<br><<br><<br><br><<br>Leaves or shoots distorted<br>< |
| ><br>Bolls with spots or dead areas, or completely dead<br>>                                  | Bacterial blight<br>Boll rot<br>Boll dangle<br>Boll damage                                                                                                                        |                                                                            |





# Are you at risk of Cotton Bunchy Top (CBT)?

*The wet late winter/spring in 2010 has taken what was a very low level of CBT incidence to one that is highly visible in many cotton crops and volunteers late in the season, with some crops having severe yield impacts. Actual yield losses in 2010–11 are lower than 1998/99 (estimated at about 25% yield loss on 21% of the area equal to 5.2% loss across the whole industry and \$140/ha). However, a winter/spring conducive to volunteer/ratoon, weed, aphid & CBT survival, could affect your yield next season.*

***Can you afford to let CBT affect your crop?***



## Over-winter risk factors for CBT

☐ ***Do you have any volunteer or ratoon cotton on your farm?***

CBT can only survive in living plants. Host plants, especially volunteer and ratoon cotton become the bridge that allows the virus to continue season to season. Elimination of hosts, particularly over winter, is the most effective means of minimising the risk of CBT and will also remove an important over winter host for cotton aphid.

☐ ***Do you have any broadleaf weeds?***

Good on-farm management of broadleaf weeds is important as they can also host aphids and some may be hosts for CBT.



## What is CBT?

CBT is a viral disease that is spread by cotton aphid (*Aphis gossypii*). While cotton can compensate for a proportion of plants being infected, if the proportion of CBT infected plants is too high (>15–20% plants), there can be serious yield implications.

CBT is characterised by small leaves, short internodes and small bolls. Leaves usually have pale green angular patterns around the margin with darker green centres and will have a leathery texture. Crops affected as seedlings, take on a compact, stunted, 'climbing ivy' appearance. There is a 3–5 week delay from infection to obvious symptoms. Symptoms are difficult to distinguish in older volunteer cotton and late crops (post cut out) where there has been insufficient new growth to show symptoms.

**For more information refer to the CBT tech note available from [www.cottoncrc.org.au](http://www.cottoncrc.org.au)**



# Preparing your crop for harvest

By **JAMES HILL**

Acknowledgements: Michael Bange, Greg Constable, Stuart Gordon, Rob Long, Geoff Naylor and Rene van der Sluijs (CSIRO)



## The key to effective defoliation

### Effective cutout

Cutout: Is as the cotton plant continues to develop bolls, the demand for carbohydrates that are produced in the leaves increases.

Eventually the demand by the bolls exceeds supply, resulting in the production of new fruiting nodes ceasing and the shedding of excess bolls, less than 14 days old. This point is known as 'cut-out'. An approximation of the timing of cutout is when a crop has reached on average 4 nodes above white flower (NAWF). The cutout date should aim to optimise yield and quality allowing squares and bolls on the plant to mature and open, enabling harvest prior to cool/wet weather.

### Management tips

- Monitor cutout at least weekly using the Nodes Above White Flower (NAWF) technique. NAWF = 4 is generally the accepted time of cutout.
- Use the CottASSIST Crop Development Tool to assist you to track your crop's rate of cutout compared with the optimal rate.
- Crops approaching cutout too rapidly are stressed (either not enough water or nutrition or carrying a very high fruit load). So use a strategy to provide new growth such as irrigation or nutrition.
- Consider how much time is left in the season. This can be done by estimating the date of the last effective flower (See Table 1). This can be determined through

## BE AWARE OF

- Apply the appropriate harvest aid at the correct time for a timely, efficient and clean harvest.
- Manage the crop to ensure timeliness of harvest to lessen the risk of weather or frost damage
- To avoid regrowth issues it is prudent not to defoliate an area bigger than can confidently be harvested within 2 weeks

Further information and support is available through the Fibre Quality module in *myBMP*.

the CottASSIST Last Effective Flower Tool. This tool can be used to select your own data using your nearest weather station.

- Crops approaching cutout too slowly can indicate that there has been a loss of fruit and/or plenty of water and nutrition. These crops should be monitored to determine if a growth regulant is necessary. Use the CottASSIST Crop Development Tool to check your VGR (Vegetative Growth Rate).

**TABLE 1.**

Average dates for the last effective flower for various locations for different times when crops are expected to finish. These have been calculated by the CottASSIST Last Effective Flower Tool ([www.CottASSIST.cottoncra.org.au](http://www.CottASSIST.cottoncra.org.au)) using historical climate data since 1957.

| Average target date of your last effective flower |                                                                             |          |          |          |          |
|---------------------------------------------------|-----------------------------------------------------------------------------|----------|----------|----------|----------|
| Town                                              | Date when you want your crop to be finished (Date of last harvestable boll) |          |          |          |          |
|                                                   | 1st Mar                                                                     | 15th Mar | 1st Apr  | 15th Apr | 1st May  |
| Jerilderie                                        | 30th Dec                                                                    | 11th Jan | 22nd Jan | 30th Jan | 5th Feb  |
| Griffith                                          | 31st Dec                                                                    | 12th Jan | 24th Jan | 31st Jan | 7th Feb  |
| Hillston                                          | 5th Jan                                                                     | 17th Jan | 29th Jan | 5th Feb  | 12th Feb |
| Warren                                            | 6th Jan                                                                     | 18th Jan | 29th Jan | 6th Feb  | 13th Feb |
| Bourke                                            | 13th Jan                                                                    | 25th Jan | 6th Feb  | 15th Feb | 22nd Feb |
| Walgett                                           | 11th Jan                                                                    | 22nd Jan | 4th Feb  | 13th Feb | 20th Feb |
| Wee Waa                                           | 8th Jan                                                                     | 20th Jan | 2nd Feb  | 10th Feb | 18th Feb |
| Gunnedah                                          | 4th Jan                                                                     | 16th Jan | 29th Jan | 6th Feb  | 14th Feb |
| Spring Ridge                                      | 31st Dec                                                                    | 12th Jan | 24th Jan | 1st Feb  | 9th Feb  |
| Moree                                             | 8th Jan                                                                     | 20th Jan | 2nd Feb  | 11th Feb | 20th Feb |
| Mungindi                                          | 11th Jan                                                                    | 23rd Jan | 5th Feb  | 14th Feb | 22nd Feb |
| St George                                         | 12th Jan                                                                    | 24th Jan | 6th Feb  | 15th Feb | 23rd Feb |
| Goondiwindi                                       | 8th Jan                                                                     | 20th Jan | 2nd Feb  | 11th Feb | 19th Feb |
| Dalby                                             | 2nd Jan                                                                     | 14th Jan | 28th Jan | 6th Feb  | 15th Feb |
| Theodore                                          | 9th Jan                                                                     | 21st Jan | 5th Feb  | 15th Feb | 25th Feb |
| Emerald                                           | 11th Jan                                                                    | 24th Jan | 7th Feb  | 18th Feb | 28th Feb |

### Season length

Season length is another consideration that effects defoliation and harvest. Short growing seasons as experienced in southern & eastern growing regions should consider sowing as early as feasibly possible to avoid crops maturing and being harvested in cold and wet conditions.

## Ceasing crop growth for a timely harvest

Late flowering and especially regrowth will cause fibre quality problems directly which will be reflected in reduced micronaire and increased neps, and indirectly





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with poorer grades. Delayed harvests also expose clean lint to increased chances of weathering. Humid conditions or rainfall increases microbial damage thereby potentially reducing colour grades. Poor and untimely defoliation can have a significant impact on fibre maturity as well as the amount of leaf trash.

Management considerations from open boll to harvest include:

- Appropriate irrigation management for finishing the crop and avoiding regrowth.
- Managing aphid and whitefly infestations to avoid sticky cotton.
- Accurately determining crop maturity.
- Ensuring timeliness of harvest operations to avoid wet weather.
- Effective application of harvest aids.

A perfect system to attain the highest quality cotton would be to have a field with 70–80% mature bolls, generated from uniform flowering and boll retention resulting in an abrupt cutout that had ample water and nutrition to meet only those requirements of the fruit present at cutout. Leaves would have matured naturally and allowed for easy defoliation at an appropriate time when temperatures were warm. The crop would be ready to harvest when the chances of rainfall were small.

### Irrigation management for finishing the crop

Crop management to synchronise crop maturity dates and harvesting operations with climate and weather is one aspect of timeliness. Excess nitrogen rates (see sowing to first flower chapter of FIBREpak) or events which cause late regrowth (e.g. excess soil moisture at harvest) can interfere with defoliation practices and picking. Delayed growth may also mean that fibre development may also occur in cooler weather (reducing fibre maturity, lowering Micronaire).

Unnecessary and late season growth also supports late season insects which can damage yield and quality by feeding on developing bolls (*Helicoverpa*) and secreting

honeydew that can cause stickiness (whitefly and aphids). In wet or humid weather leafy crops may also contribute to boll rot.

Timing of last irrigation is a balance between ensuring (1) there is enough moisture to allow the growth and maturity of harvestable bolls, and (2) fields are dry enough to assist defoliation, limit regrowth, and minimise picking delays and soil compaction. The moisture required for late crop growth is related to the time of defoliation. The broad aim is to plan to manage irrigations effectively to finish the crop and to limit regrowth by having soil moisture levels to refill points by defoliation.

### Determining end of season crop water requirements

End of season water requirements can be estimated from the date of the last effective flower which is when the Nodes Above White Flower (NAWF) measurement is equal to 4. The last harvestable bolls take 600 to 650 degree days to reach crop maturity. Therefore for crops to be defoliated towards the end of March, the last effective flower needs to occur in the last week of January. Crop water use needs to be considered for this period. At the time of first open boll, crop water use may be 5–7mm per day and may decline to around 4mm per day prior to defoliation.

Factors to consider:

- Days to defoliation;
- Boll maturity;
- Crop water use;
- Plant available water – ability to extract water below normal refill point; and,
- Soil moisture objective at defoliation.

### Days to defoliation

(General example – need to generate values for your own district)

- Defoliate when Nodes Above Cracked Boll (NACB) is equal to 4.
- Takes 42 degree days, around 3 days (up to 4 days in cooler regions) for each new boll to open on each fruiting branch.
- $(\text{Total NACB} - 4) \times 3 = \text{days to defoliation}$ .
- Aim to be at or close to refill point at time of defoliation.

### Crop maturity is monitored to avoid early crop cessation

To determine crop maturity monitor plants that are representative of the crop.

Methods include:

% bolls open – Crops can be safely defoliated after 60–65% of the bolls are open. This method is simple and works well in crops with regular distribution of fruit.

NACB (Nodes above cracked boll) – In most situations 4 NACB equates to the time when the crop has 60% bolls open. This is a useful methodology on crops that are



Defoliated cotton ready to be picked.

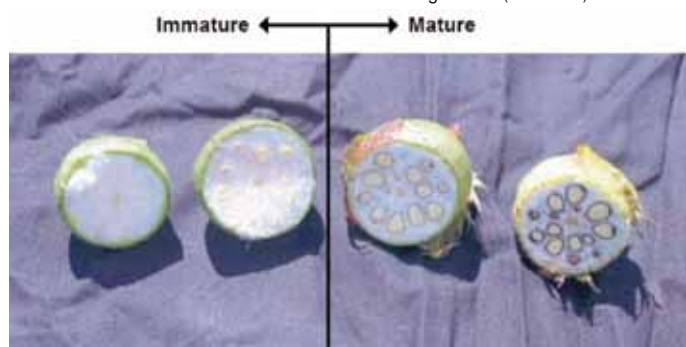


uniform in growth, and is less time consuming than % open bolls.

**Boll cutting** – The easiest and probably the most effective method to determine if bolls are mature or immature. It can be used effectively even when crops are not uniform (e.g. tipped out plant, gappy stands). Bolls are mature when: they become difficult to cut with a knife; the seed is well developed (not gelatinous) and the seed coat has turned brown (see Figure 1); and when the fibre is pulled from the boll it is stringy (moist but not watery).

**FIGURE 1.**

Bolls that are mature have seed coats that are turning brown. (Photo: CSD)



### Whitefly and aphid infestations are monitored and managed to avoid sticky cotton

A significant proportion of all cases of stickiness are attributable to honeydew exudates of the silverleaf whitefly (*Bemisia tabaci* B-biotype) (SLW) and the cotton aphid (*Aphis gossypii*). The sugar exudates from these insects lead to significant problems in the spinning mill.

Presence of honeydew on the surface of cotton late in the season can also contribute to reductions in grade as it provides a substrate for sooty moulds and other fungal growth. In humid conditions the growth of fungal spores along with honeydew can increase the grey colour of the lint.

SLW and aphids prefer to feed on the under surface of the leaf allowing the small transparent droplets of honeydew to fall to leaves and open bolls below. The level of contamination by honeydew is directly dependant on the numbers and species of insects present. Control of these pests is especially important once bolls start to open.

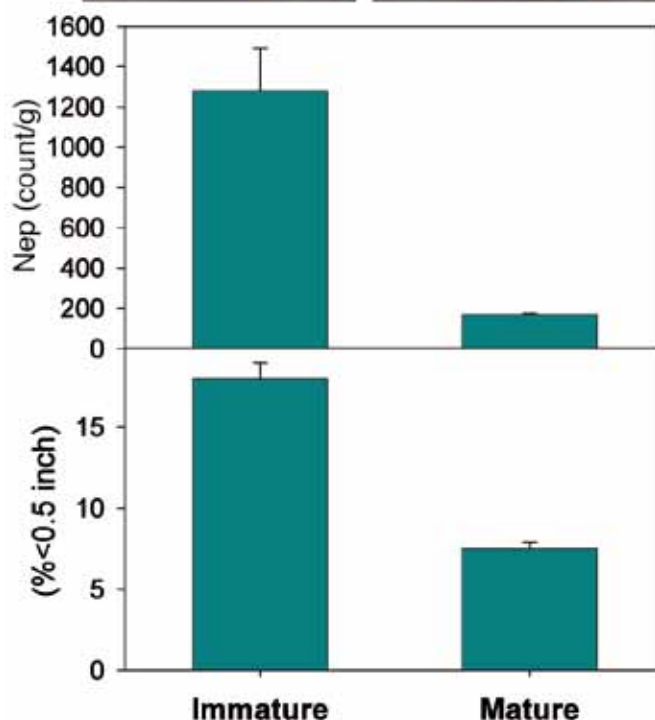
### Timeliness of harvest operation

Cotton that is severely damaged from weather is also undesirable in textile production because the lint surface has deteriorated and this is perceived to have dye uptake problems. It also can increase the roughness of the fibre which alters its frictional properties and thus how the fibre performs in the spinning mill.

As cotton weathers it loses reflectance, becoming grey due to moisture from both humidity and rain, exposure to ultraviolet radiation (UV) and from fungi and microbes that grow on the lint or wash off the leaves. Damage to the fibre will reduce micronaire as the fibre surface becomes rough retarding air movement in the

**FIGURE 2.**

Pursuing late bolls may put fibre quality at risk. Un-fluffed immature bolls contribute little to yield but significantly increase neps and short fibres. (Rob Long, CSIRO)



micronaire chamber. Weathering will also reduce fibre strength making fibres susceptible to breakage during the ginning process, reducing length and increasing short fibre content leading to issues in yarn production.

When a boll opens under humid conditions microbes begin to feed on the sugars on the surface of the fibre and stain the lint. Under very humid conditions fungi can multiply on the lint causing 'hard' or 'grey locked' bolls which can reduce both quality and yield.

If bolls are opened prematurely by frost often it has a yellow colour that varies with intensity of the frost. Injury to moist boll walls as a result of frost damage releases gossypol which stains the cotton yellow.

A grower should examine their harvest capacity, regional weather patterns, and have monitored their crop development to avoid excessive weathering.

Specific considerations include:

- Time harvest to avoid excessive rainfall once bolls are open. Tools to assess rainfall frequency include: Rainman (<http://www2.dpi.qld.gov.au/rainman/>), <http://www.bom.gov.au/climate/averages/>
- Plan to have the crop defoliated before first frost.

**TABLE 2.**

Dates of first and last frost for cotton production (Source of climate data <http://www.longpaddock.qld.gov.au/silo/>)

| Region      | Years of Climate Data | Average Date of First Frost | Date of Earliest Frost Recorded |
|-------------|-----------------------|-----------------------------|---------------------------------|
| Emerald     | 111                   | 9 Jun                       | 23 Apr                          |
| Dalby       | 111                   | 26 May                      | 17 Apr                          |
| St George   | 43                    | 7 Jun                       | 7 May                           |
| Goondiwindi | 107                   | 2 Jun                       | 23 Apr                          |
| Moree       | 111                   | 28 May                      | 12 Apr                          |
| Narrabri    | 43                    | 25 May                      | 27 Apr                          |
| Gunnedah    | 62                    | 22 May                      | 11 Mar                          |
| Bourke      | 43                    | 12 Jun                      | 10 May                          |
| Warren      | 43                    | 27 May                      | 27 Apr                          |
| Hillston    | 43                    | 17 May                      | 1 Apr                           |

See Table 2 or use the last effective flower tool on the CottASSIST website which can be used to identify the timing of first frost for your locality.

### Effective application of harvest aids

Defoliation induces leaf abscission which is the formation of a break in the cellular structure joining the leaf to the stem allowing the leaf to fall off. Leaf removal is critical for reducing the amount of leaf trash in machine harvesters. These chemicals allow timely and efficient harvest of the lint to reduce quality losses from weathering and leaf stain from excess leaf trash. Boll opening is also accelerated by defoliation as removal of leaves exposes bolls to more direct sunlight, promoting increase temperatures for maturation, and drying and cracking of the boll walls.

Application of harvest aids are determined by: the timing, the type of chemical used, and the rates applied. The effectiveness of harvest aids is dependent on: uniformity of plant growth, weather conditions, spray coverage, and adsorption and translocation of the chemical by the plant. Optimum timing of harvest aids must strike a balance between further boll development

and potential losses from adverse weather and the inclusion of immature fibre which can lower micronaire and increase neps (Figure 2). Avoiding regrowth resulting from residual nitrogen and moisture in the soil will also contribute to harvest aid effectiveness, as regrowth plants have high levels of hormones that can interfere with defoliation.

### Types of harvest aids

The categories of harvest-aid chemicals include herbicidal and hormonal defoliants, boll openers, and desiccants each with a different mode of action:

**Defoliants** (Thidiazuron, Diuron, Dimethipin) – All defoliants have a common mode of action to remove leaves. They increase the ethylene concentration in leaves by reducing the hormone auxin and/or enhancing ethylene production. Dimethipin alters the concentration of ethylene by reducing the amount of water in the leaf stimulating ethylene production. This change in ethylene concentration triggers separation in the abscission zone at the base of the petiole (leaf stalk). Chemical defoliant enters leaves through the stomates (minor route) or through the leaf cuticle (major route). Hormonal defoliants are applied to reduce auxin and/or enhance ethylene production, while herbicide defoliants injure or stress the plant into increasing ethylene production (similar to waterlogging or drought effects). If herbicide defoliants are applied at too high rates the plant material may die before releasing enough ethylene to cause defoliation resulting instead in leaf desiccation (leaf death).

**Boll openers/conditioners** (Ethephon, Cycilanillide, Aminomethanane Dihydrogen Textrooxosulfate) – These chemicals specifically enhance ethylene production by providing a chemical precursor for the production of ethylene, which leads to quicker separation of boll walls (carpels).

**Desiccants and herbicides** (Sodium Chlorate, Magnesium Chlorate, Glyphosate, Diquat, Paraquat) – Desiccants are contact chemicals that cause disruption of leaf membrane integrity, leading to rapid loss of moisture, which produces a desiccated leaf. Desiccants should be avoided as they dry all plant parts (including stems) which can increase the trash content of harvested lint. Sometimes it is necessary to use desiccants if conditions do not enable the effective use of defoliants (e.g. very cold weather). Desiccants are also a reliable method to reduce leaf regrowth. High rates of some defoliants can act as desiccants.

### Timing of the application of harvest aids

The type of defoliation product is unlikely to impact on fibre quality if timing is correct, however, early defoliation can cause a significant reduction in all desirable fibre properties. Too early defoliation will increase the number of bolls (often from the top of the plant) harvested that have immature fibre with reduced fibre strength and micronaire. This may cause fibres





to break during ginning lowering fibre length and uniformity and increasing short fibre content and neps. It is important to note that immature fibre will not allow for correct assessments of fibre strength using High Volume Instrument (HVI).

Application of defoliations earlier than 60% of bolls open will reduce micronaire and increase neps. In crops that have non-uniform maturity it is advisable that there be no more than 29% immature bolls (of total boll number) that are defined as immature bolls using the boll cutting technique, to avoid increasing neps.

### Key issues for use of defoliants

- Ensure defoliation practices occur before the onset of frost.
- Aim to have soil moisture at refill points at defoliation. Severely water stressed crops will not allow defoliants to act effectively.
- If boll openers/conditioners are applied prior to boll maturation they may cause bolls to shed and reduce yield
- The use of boll opener/conditioners should only be considered if the bolls that will be forced open are mature.
- Avoid application of defoliants when there is a risk of rainfall shortly after. Some defoliants are taken up slowly by the leaves and will wash off by rain, resulting in incomplete defoliation.
- To avoid regrowth issues it is prudent not to defoliate an area bigger than can confidently be harvested within 2 weeks.

### Rate and chemical selection issues

- Varieties can sometimes differ in the needs for defoliation as they can differ in the quantity of wax on the leaf surface which affects harvest aid uptake, and plant hormone concentrations.
- Leaves most susceptible to defoliant are older leaves. Higher rates of defoliant will be needed for young healthy leaves. However, there is a chance that young leaves may 'freeze' on the plant if defoliant is applied in too warm weather.
- Cool temperatures, low humidity and water stress prior to defoliant application can increase the waxiness and thickness of the leaf cuticle reducing the efficiency of chemical uptake. Wetting agents or spray adjuvants can assist with this problem.
- Because leaf drop requires production of enzymes, the speed with which a leaf falls off is highly dependant on temperature. There are different optimal temperatures for defoliant performance. Hormonal defoliants and boll conditioners have a higher optimal minimum temperature of around 18°C compared with herbicide defoliants that have optimal minimum temperatures ranging from 13 to 16°C. Higher rates are often needed to offset the effects of low temperatures.
- The defoliating effects of a chemical are usually complete 7 days after application.

### Application issues

- Low humidity during application decreases uptake because chemicals dry rapidly on the leaf.
- For penetration of defoliants lower into the canopy consider using larger droplet size or directed sprays in the case of ground rig use. Use of spray adjuvants may decrease droplet sizes and this may work against chemical penetrating deeper into the canopy.
- Many growers use combinations of defoliants with different modes of action and multiple applications to enhance defoliation. Multiple applications are beneficial because leaves deep in the canopy can be covered fully.
- If increased waxiness of the leaves is suspected, applying the defoliant in warmer conditions can assist chemical penetration as the waxy layer is more pliable.

**Refer to the Cotton Pest Management Guide and manufacturers details for specific chemical defoliation options and rates.**

These guidelines have been extracted from FIBREpak – A Guide to Improving Australian Cotton Fibre Quality.

Further information:

FIBREpak – [http://www.cottoncrc.org.au/content/Industry/Publications/Fibre\\_Quality/FIBREpak.aspx](http://www.cottoncrc.org.au/content/Industry/Publications/Fibre_Quality/FIBREpak.aspx)

CottASSIST – [www.CottASSIST.cottoncrc.org.au](http://www.CottASSIST.cottoncrc.org.au)

Cotton Pest Management Guide – <http://www.dpi.nsw.gov.au/agriculture/field/field-crops/fibres/cotton/cotton-pest-management-guide>

myBMP – [www.mybmp.com.au](http://www.mybmp.com.au)

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# Harvesting & delivering uncontaminated cotton

By **JAMES HILL**

Acknowledgements: Michael Bange, Greg Constable, Stuart Gordon, Rob Long, Geoff Naylor and Rene van der Sluijs (CSIRO)



## Contract cotton picking

Due to the expansion of the cotton industry this season there may be a shortage of contract harvest machines. The first decision to be made is to either pick the cotton yourself or use an experienced contractor. There are advantages

and disadvantages with both options.

### Advantages of using a contractor

- Do not have to pay for machinery only utilised for short period of time.
- Picking (traditional basket machines) is labour intensive.
- Generally contractors are professional and therefore should be more efficient.

### Disadvantages of using a contractor

- May be hard to source contractors due to the expansion in area.

## BE AWARE OF

- Regular maintenance and correct set up of pickers is conducted for a clean and effective harvest.
- Farm hygiene practices are in place to avoid contamination, especially when constructing modules.
- Ensure a picking contractor is organised prior to planting crop if not using own machines!
- Budget for the plastic wrap for round bales to avoid shortages.
- Ensure picker is maintained early ready for harvest.
- Ensure all staff aware of OH&S issues associated with harvest.

**FIGURE 1.**

Spindle pickers require regular maintenance to operate at high efficiency.



- Contractors may be delayed at previous farm therefore exposing your crop to potential downgrades due to weather.
- May be more costly yet this will depend on area and a number of other factors.
- Might only have a small area mature yet a contractor will not want to move until there is continuity of work.
- Risk of weed and disease spread unless machinery is cleaned thoroughly.
- Contractors may not be set up for your row space.

### OH&S

It is vital that all contractors and own farm staff go through a safety induction in cotton harvest. A good starting point is the CRDC safe harvesting DVD.

## Use of a properly maintained picker that is setup correctly

The two types of mechanical harvesting equipment are:

- The Spindle picker which is a selective-type harvester that uses tapered, barbed spindles (Figure I) to pick seed-cotton from bolls; and,
- The cotton stripper which is a non-selective, once-over harvester that removes not only the mature opened bolls but also the cracked and unopened bolls along with the burrs (carpel walls), plant sticks, bark and other foreign matter – stripper harvesting can increase ginning costs and result in lower grades.

Generally agronomic practices that produce high quality uniform crops contribute to harvesting efficiency. Soil should be relatively dry in order to support the weight of the harvesting machinery and avoid unnecessary soil compaction. Row ends should be free of weeds and grass



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and should have a field border for turning and aligning the harvesters with the rows. Banks in drains should not be too steep an angle. Plant height should not exceed about 1.2 m for cotton that is to be picked and about 1.4 m for cotton that is to be stripped.

Spindle pickers are complex machines that require proper maintenance and adjustments to operate at high efficiency. Special care should be given to the spindles, moistener pads, doffers, bearings, bushings, and the cam track. Proper maintenance and correct setup of pickers will help to ensure a clean and effective pick. Your best source of information about picker maintenance and setup is your picker operator's manual.

Moisture is added to the spindles to keep them clean and to enhance the adherence of the fibre to the spindle and allow for its removal by the doffer. Spindles generally require less moisture in the morning than in the afternoon.

### Pre season maintenance includes

- Replacing bent, broken or worn spindles. As a rule of thumb a sharp spindle will draw blood if you were to run your hand over it.
- Doffers need to be ground and reset properly each year. Replace if damaged.
- Check moisture pads, bar heights, grid bars. Moisture pads should wipe each spindle clean to remove plant secretions that may cause spindle twist.
- Check pressure doors for wear, bends and alignment.
- Clean picker basket.
- Check hydraulic and air hoses for leaks.
- Ensure drive belts and universal joints in the drive train are in good condition.

### Daily setup and checks include

- Greasing picker heads – recommended when picker heads are warm. Some systems also require light greasing every two to four hours throughout the day. Spin heads to remove excess grease and wash down if excess still remains.
- Ensure head heights are set correctly (too high bolls are not harvested, too low soil and trash are collected).
- Ensure correct setting of pressure doors for crop conditions. Dented or worn doors cause inefficient picking. Adjust doors to allow efficient removal of lint but avoids excessive bark removal.
- Doffers need to be checked daily and throughout operations. Too much clearance leads to improper doffing and spindle twist while lack of adequate clearance leads to abrasion of doffer plates by the spindles leading to presence of rubber specks (often not detected until textile manufacture).
- Picking units should be inspected on a regular basis when a basket is dumped or for a round baler perhaps every 4 round modules. This will help detect spindles that have not been wiped or are dirty (causing spindle wrap). If problems occur check water system and



Picker and boll buggy.

doffers. Remove any build-up of trash to prevent excessive accumulation before the unit chokes.

- Use a recommended spindle cleaner with the correct nozzles (especially if there is green leaf present on the plants).
- Perform regular cleaning of the picking basket (fly cotton causes quality problems and is also a fire hazard). Dispose of fly cotton where it cannot contaminate the module.
- Adjust water rates correctly according to the time of day and picking conditions. Higher rates are usually needed in the middle of the day when conditions are drier.
- To avoid picking green bolls, pressure doors should be set to light to medium and all grid bars should be in position.
- Avoid picking areas that are extremely grassy that have the potential to contaminate cotton and reduce grades.

Templates are available in the Fibre Quality module in *myBMP* to help with pre-season and daily picker checks.

### Avoiding harvest operations when cotton is wet

Cotton that is picked wet will result in cotton being twisted on the spindle (spindle twist – roping that occurs when spindles are partially doffed) which may lead to seed cotton being more difficult to process in the gin. Moist cotton during the ginning process can also mean that excessive drying is needed which also causes fibre damage. The harvesting operation itself is also interrupted as picker doors are blocked more often when cotton is too moist and efficiency declines as a result of poor doffing efficiency, i.e. no flow out of the basket. Doffers and moisture pads on pickers can also be damaged.

Typically cotton is too moist for harvest at dawn in Australia but cotton can be picked well into the night provided relative humidity remains low. Moisture monitoring needs to be more frequent at each end of the day as the change in moisture can be quite abrupt, e.g. moisture can increase abruptly from 4% to 6% within 10





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minutes as night and dew point temperature fall rapidly. Harvesting seed-cotton in excess of 12% moisture is not recommended.

If wet cotton is processed into a module in the field it will also increase the risk of the module self combusting or lowering the grade due to yellowing or spotting associated with fungal contamination.

Modules during storage on-farm and in the gin should be monitored every five to seven days for temperature rises. A rapid temperature rise of approximately 8 to 11°C or more in 5 to 7 days signifies a high moisture problem and that module should be ginned as soon as possible. Modules that have temperatures rising to 43°C need to be ginned immediately. The temperature of modules harvested at safe storage moistures will not increase more than 5.5 to 8°C in 5 to 7 days and will level off and cool down as storage period is extended.

Some rules of thumb to consider relating to moisture on cotton to be harvested include:

- If moisture is present on vehicles while harvesting it is most likely that the cotton is too wet.
- The seed should feel hard (cracks in your teeth)
- If you can feel moisture on the cotton it is too wet. Seed cotton measured on a moisture meter should be less than 12%.
- Consider that machine picking can also add 2% moisture to seed cotton.
- A symptom of moist cotton is frequent blocked doors, throwing cotton out the front of the picking heads.
- If cotton is being expelled into the basket in dense blobs and is not fluffy it may be too moist.
- Suitable picking conditions late into the night are rare.
- Notify your ginner of modules that may be moist so that they may be ginned first, or at least monitored in the module yard.

### Guidelines for module placement, construction, tarping and transport

Key considerations for module production to maintain quality are module placement, construction, tarping, storage and transportation to the gin. Another important consideration is ensuring personnel involved in module building are instructed and observe a sanitary workplace in terms of contamination. Workers should abide by the dictum that no unworn clothing, rags, papers, tools, non-cotton ropes, tarps (with exception of the module tarp), lunch bags etc. be left in and around the module making work site. In addition cotton is highly flammable and it is essential that workers do not smoke near cotton modules.

### Bale pickers

The introduction of on board module building capacity on pickers (Figure 2) has offered opportunities to growers to undertake non-stop harvesting and eliminate in-field unloading to boll buggies and processing in module builders. This picking process may potentially save time, fuel, and labour and maybe allow simpler segregation of

**FIGURE 2.**

Round modules and small modules automatically made and discharged from pickers avoid to a large extent the problem of contamination, although contamination from tarps and coverings, which need to be removed before ginning, remains an issue. (Photo: John Deere)



cotton of differing quality. While management processes using these systems will differ and alleviate some of the issues discussed below many of the principles will, however, still apply.

### Module and bale placement

Incorrect placement of modules has the potential to contribute to significant losses caused by moisture damage as well as contributing to contamination. The following guidelines should be considered when choosing a site for module placement:

- Module pads should have enough space to allow easy access for the equipment and trucks.
- Located near a well-drained field road and avoiding areas where water accumulates.
- Site free from gravel, stalks, and debris such as long grass or cotton stalks.
- Smooth, even with firm, compacted surface that allows water to drain away.
- Accessible in wet weather.
- Away from heavily travelled dusty roads, and other possible sources of fire and vandalism.
- Clear of overhead obstructions such as power lines.

### Module construction

A module builder compact's seed-cotton to a density of about 190 kg/cubic m. A tighter module better sheds rainfall on the sides and less cotton is lost during storage, loading and hauling. The top of the module should be rounded to allow it to shed water when covered. In addition a well compacted module will help reduce freight costs to the gin.

Good communication is needed between module-builder operators, picker and boll buggy drivers to allow appropriate time for modules to be built and to avoid spillages. Cotton that is spilled from modules



should be carefully added back into the module avoiding contamination whilst following strict OH&S guidelines.

A constant lookout for oil leaks on both cotton pickers and the module builders is needed to prevent contamination. Oil leaks on builders should be repaired as soon as they are noticed. Oil contaminated cotton needs to be removed from the module as soon as it is identified.

### Module tarping

Use of a high quality tarpaulin on modules is important to avoid moisture affecting quality as well as avoiding significant contamination of the cotton from the tarpaulin itself. Before using tarpaulins inspect them for holes and that they still repel water before use.

Tarpaulins should be chosen considering their tensile strength to avoid tearing, resisting puncturing and abrasion, adhesion of coatings, UV resistance, and cold crack temperature. If tarpaulins have seams they should be double stitched, with a minimum number of stitches. Centre seams (unless heat sealed) should be avoided as it is a potential weak point to allow water to enter the module. All these factors should be weighed up in light of the overall cost of the tarpaulin and its life expectancy.

To avoid contamination and fibre quality losses tarpaulins need to be securely fastened to the module. For best performance of tie-down type module covers use all loops and grommets provided. Cotton rope is the most appropriate fastener to limit contamination and synthetic rope should never be used. Ensure rope has enough strength to endure strong winds. Belly ropes should be avoided if possible as they may break. A tarp should be large enough to cover at least half to two thirds of the modules on the ends.

### Module transportation

- Truck and trailer beds need to be cleaned prior to picking up the module (A rake should be provided).
- No loose cotton to be added to module when loading.
- All loads to be properly covered.
- Truck beds to be cleaned down after unloading.

### Round module transportation

**The Load Restraint Guide requires each module to be individually restrained.**

On open sided semi-trailers, the round bale modules can be loaded either 'wagon wheel' or 'sausage' configuration. From the point of view of managing the risk that the sides of individual round bale modules may bulge beyond the statutory load width of 2.5 metres once restraint straps are tensioned, the 'wagon wheel' option is the preferred loading configuration.

**Caution:** Round bale modules loaded on open sided flat-top trailers in the 'sausage' configuration are much more likely to expand beyond the trailer sides once restraint straps are tensioned.

If any section of a round bale module extends beyond

the statutory maximum width of 2.5 metres when loaded on a flat-top trailer, then the entire load is deemed to be over-width. In this situation you may not be legally able to operate under an over-width notice due to the multiple number of round bales on the trailer determined as a 'divisible' load.

**Refer to: Cotton Australia 'Module Load & Restraint Guide – 2011 Edition.**

### Keeping good module records

Identifying when and where each module is produced can help with producing better fibre quality outcomes as the grower can discuss with the ginner the quality of the cotton of each module and thus tailor the ginning process to suite. The grower can also use these records to better understand the variability that exists in fields to refine management practices for that particular field in subsequent seasons.

Each module should have a record (with a duplicate kept in a safe place), which includes the date and weather conditions when picked. Any records or numbers assigned to modules should be as permanent as possible. Permanent marker pens should be used on cards attached to modules in a sealable plastic bag.

If a module is suspected of having a contaminant, clearly identify it, and notify the gin when delivering the module of the potential problem.

**An example module information form can be found in the Fibre Quality module in myBMP.**

**These guidelines have been extracted from FIBREpak – A Guide to Improving Australian Cotton Fibre Quality.**

**Further information:**

**FIBREpak – [http://www.cottoncra.org.au/content/Industry/Publications/Fibre\\_Quality/FIBREpak.aspx](http://www.cottoncra.org.au/content/Industry/Publications/Fibre_Quality/FIBREpak.aspx)**

**myBMP – [www.mybmp.com.au](http://www.mybmp.com.au)**

**CRDC Safe Harvest DVD phone: 0267 924088**

**Cotton Australia 'Module Load & Restraint Guide' 2011 Edition**

**Pick N Match – On Cotton Australia website if in need of a contractor**

**To register as a contractor email Cotton Australia on [talktous@cotton.org.au](mailto:talktous@cotton.org.au)**

# Managing cotton stubble/residues

By **DALLAS KING & IAN ROCHESTER**



**Dallas King.**



**Ian Rochester (CSIRO).**

Returning cotton stubble to the soil provides a source of energy for the microbial biomass, which in turn helps the breakdown of stubble. This maintains the supply of nutrients to the crop. Organic matter enhances the health of the soil, as higher organic matter drives better water infiltration and internal drainage.

## Avoiding soil compaction

Cotton pickers are very heavy, with front axle loads as great as 14 tonnes for conventional pickers and about 40 tonnes for a fully loaded round module picker. However, when the soil profile is dry at harvest, their impact on soil structure is less than when the soil is moist, although wide tyres or dual front wheels will compact loose beds.

It must be remembered, that serious soil compaction may have occurred earlier in the season (due to operations such as fertiliser application and weed control), or remain from previous seasons when the soil has had insufficient time to restore its structure. Soils may take years to

recover from structural damage and many wetting and drying cycles assist this process.

A big advantage of a dry harvest is that it gives you the widest possible range of options for preparation and improvement of cracking clay soils, provided that heavy rain does not follow soon afterwards. Cultivation, and particularly deep tillage should only be attempted when the soil is dry. On non-swelling silty soil, however, dust production may be a problem if it is tilled when dry. When these soils are re-wetted rapidly, they will have poor structure.

## Pupae control

When preparing soil after a dry harvest, the first priority is to deal with the over-wintering pupae of *Helicoverpa armigera*. They are a key risk of increasing resistance to Bt in Bollgard II® cotton and to insecticides. A tillage strategy must be implemented to destroy the pupae by the end of July (as per the Bollard II Resistance Management Plan), while avoiding serious structural damage to the soil and minimising input costs.

Tillage to a depth of at least 10cm is most likely to kill overwintering *Helicoverpa* pupae, if all of the very large clods (more than 50mm wide) in the topsoil have been broken down and rearranged. However, be careful on silty soil where aggressive dry cultivation will create dust and destroy soil structure.

For further information on pupae control refer to the Integrated Insect and Mite Management chapter.

## 'Volunteer' and 'ratoon' cotton

Due to the advent of herbicide tolerant cotton cultivars in the past decade, cotton residue management has become an extremely important consideration for cotton producers utilising the technologies.

'Volunteer' or 'ratoon' cotton provide an excellent host (green bridge) for exotic pests such as whitefly, aphids, mites and mealy bugs to survive on-farm from one season to the next. Therefore the need to provide a high level of control has never been more pertinent.

There are several factors which will determine the choice of operation to eliminate the current crop residue effectively (see Residue Management Options below). These will include, equipment availability and the moisture status of the soil.

## Cotton stalk management

Crop residues can carry disease, clog tail drains, interfere with herbicide incorporation and with planting. However, stubble incorporation may improve the amount and quality of soil organic matter. Burning of cotton stalks should be avoided as nutrients will be lost and soil carbon levels will decline quickly.

Soon after harvest the stalks should be cut finely enough to avoid immediate management problems such as implement blockage. If the trash is broken down too finely, decomposition and nutrient release may occur too quickly

## BE AWARE OF

- Pupae control is the first priority after harvest, in Bollgard II® fields. It must be completed by the end of July.
- Preventing cotton ratoons and controlling volunteer cotton after harvest, is the second priority.
- The majority of growers utilise mulching & root cutting to manage cotton residues.
- Ratoon cotton will increase the incidence of Cotton Bunchy Top disease as well as mealy bug, aphid and whitefly infestations for the following crop.
- Poorly destroyed and incorporated crop residues will hamper planting and germination of the following crop.
- Excess stubble that enters irrigation channels creates problems for irrigation pumps.



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**"The Kronos just keeps on going, which is exactly what a contractor needs from a machine."**

**G**raham Gowar has been contracting in south-west Queensland for 18 years, 12 of them working with cotton. He discovered the strength of Howard machinery whilst farming in South Africa.

"We had two Howard slashers and they took a lot of punishment from drivers who didn't know or care about machinery. Those slashers are rugged machines and they held up very well, giving us many years of service," Graham said.

Graham's business, GMG Contract Farming, is now a family operation. His son, Bruce, will also mulch cotton this season, and bought their second Kronos 8000C flail shredder. Graham bought his first Kronos 8000C shredder three years ago after the dealers, Vanderfields, demonstrated the machine's capabilities.

"One of our clients runs a major Queensland cotton station. They saw the Kronos in action and were very happy with the results. So were we. We mulched 5000 acres of sorghum with it in the first season and made enough to pay for the machine. We've been mulching cotton since then, and we also did a trial run with pigeon peas," Graham said.

"This year, a client has asked us to mulch 16,000 acres of cotton in a month. We're aiming to have 20,000 acres done by end of the season and we wouldn't have a hope without the Kronos.

"The shredders are so rugged and reliable. The gearbox is fantastic. It takes a tremendous load, mulching eight rows of cotton stalks at once. It's like feeding wood through it, and to turn it so quickly, it's just incredible.

"The hard-faced flails are toughened with a special welding technique to give them a long life. Sometimes we work in paddocks with quite a bit of wood lying around and you can't always avoid it. I've had a flail bend slightly but they just keep working. I've never broken one yet."

Graham said before they bought their first Kronos, it took at least four passes to get the work done. "So doing a 10,000-acre mulch was like doing 40,000 acres in work terms. Getting great results with one pass is a 75 percent saving on time and labour for us so we are very happy using the Kronos."

They use two John Deere 8400 tractors with their Kronos flail shredders and Graham says if he's getting 10 km/h, he's happy.

He learned about machinery growing up on the farm and he does his own maintenance. They regularly blow down the machines with a compressor and grease them. "I believe in preventative maintenance for machinery and for the land too," he said.

"The Kronos design is very practical. Maintenance access is easy and I like the doors at the back. You don't have to lie in the dirt to take a look at the machine; you just stand there and open the doors.

"The only problem we've ever had with the Kronos was due to human error when a driver went too low, cutting into the dirt and overloading the belts. Apart from that we've had no bother at all. The Kronos just keeps on going, which is exactly what a contractor needs from a machine."



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– this can lead to loss of nutrients such as nitrogen. If the cotton disease *Fusarium* wilt is known to be present, it may be necessary to at least partially disinfect the stalks by leaving them exposed to UV light on the soil surface for several weeks – immediate stubble incorporation is likely to aggravate the *Fusarium* problem.

## Choosing a tillage and/or rotation option

You may find that the crop you have just harvested has partly or wholly fixed a compaction problem that had caused it to perform poorly. Cycles of wetting and drying during the growing cycle and deep drying by the crop after the last irrigation can crack the soil and improve structure to a point where deep tillage may not be necessary. However, residual compaction may remain; and cracking by rotation crops, and/or deep tillage, may be required to improve yields and profits of subsequent crops.

Full land preparation (ploughing the old hills and forming new ones) gives you the opportunity to ‘tidy up’ a field: removing hollows, straightening crooked rows, adjusting guess row spacing, and controlling weeds.

After examining the soil structure, assess soil moisture to determine to what depth tillage would be beneficial. The soil profile may not be at a uniform moisture content. It may be possible to till the upper, dry part of a compacted layer and leave the deeper, moist soil untouched (and unsmeared).

## Cotton residue management options

Methods for crop residue control have changed greatly since the late 1990s when ‘pull, rake and burn’ was a common option.

The main processes currently promoted in the industry include:

- Mulching of stalk above the ground and cutting the root.
- Incorporating the residues into the surface soil.

### Mulching and root cutting

The Australian cotton industry has now moved away from the practices of stubble removal and burning, and now promotes the practices of slashing and incorporating stubble due to some of the positive impacts this system has on soil fertility.

Some of the positives of the mulch and root cut approach are:

- Speedy operation.
- Root and sub section is cut in half reducing cultivation problems.
- System has been widely proven and is available in a variety of configurations.
- Residue is more easily broken down and incorporated than slashing.
- Weather conditions have less of an impact than on rake and burn operations.

- Depending on depth of root cut, some preliminary pupae control is achieved.
- Residues are mulched back into the soil as opposed to being burnt.

Some of the negatives of the mulch and root cut approach are:

- Unless the machine is set up properly ‘ratoon’ plants can become an issue in guess rows though GPS systems have helped to reduce this.
- With moist conditions trash and soil surface can build up and hamper following fertiliser applications.
- Machines are generally heavy and horsepower intensive.
- There can be more expense with maintaining machinery due to the extra components.
- Generally speaking, the cutting operation requires a much greater speed to achieve maximum efficiency

### Standard slashing

This operation focuses on slashing of the crop residue and allowing other operations to take care of the cotton stub and root system below the ground. This practice is no longer common within the industry due to the issues associated with ‘ratoon’ cotton.

### Pull, rake and burn

The pull, rake and burn process is rarely used throughout the industry as a mainstay for crop residue control. As mentioned previously this option is only generally used when growers are looking to re-laser fields and due to minimal cuts are seeking to avoid stubble becoming an issue with the laser buckets.

An experiment was conducted at Narrabri over three seasons (1992–1995) to investigate stubble management systems in relation to cotton growth, lint yield and fertiliser N recovery.

The experiment indicated that removing cotton stubble caused a reduction in lint yield and profitability over time. Compared with the lint yield of the stubble-retained treatment, the yield of the stubble-removed treatment was reduced by 3 and 9% respectively, in the second and third years of the experiment.

The experiment also revealed that the N fertiliser recovery was reduced by 10% where the stubble was removed compared to the retained plots, ie more N fertiliser was lost from the soil where stubble was removed.

A number of growers still pull cotton plants after harvest, but the stalks are then mulched using a conventional mulcher. This process allows the stubble to be returned into the soil profile during cultivation operations. Raking and burning stubble is strongly discouraged.

#### Further information:

SOILpak - <http://www.dpi.nsw.gov.au/agriculture/resources/soils/guides/SOILpak/cotton>



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# Marketing options

By **JANINE POWELL**



*The aim of this chapter is to give a general overview of the cotton pricing components and marketing alternatives available to Australian cotton growers. It is strongly recommended that growers seek advice from a reputable merchant about the alternatives suitable for their specific situation.*

## Background

Variability in the Australian cotton price is caused by fluctuations in the underlying futures prices, currency rates and basis levels. This variability can create major uncertainties (or risk) for cotton growers when deciding if to plant cotton and when to sell. It is important that growers understand the components of the cotton price, associated risks and available marketing options before they begin marketing their crop.

The ability to 'lock in' a commodity price for some or

**FIGURE 1.**

Eight years of 'cash' cotton prices available to Australian growers.  
(Courtesy of Namoi Cotton)



## BE AWARE OF

- Seek advice from a reputable cotton merchant and talk to established cotton growers about their past marketing experiences.
- Cotton seed makes up a significant part of the income from a cotton crop, discuss pricing alternatives with your chosen ginning organisation.
- Profitability of a cotton crop is heavily reliant on the price achieved for marketing. It is critical for your business to understand the marketing risks and your choices to manage them.
- Yield risk also exists when a contract is entered into after planting, but before harvest.

all of a crop before harvest can be a major advantage for cotton growers. However, fixing prices before harvest can be risky, due to uncertain production levels. To understand the different marketing alternatives it is necessary to understand the risks.

## Risk

A definition of risk: *Effect of uncertainty on objectives.* In this case returning a profit from the cotton crop is the objective and the primary areas of uncertainty (or risk) are:

- Production (quality and quantity of the cotton produced); and,
- Price (the movement of prices before they are set i.e adverse movements include an increase in input costs and decrease in commodity prices).

These risks are complex and vary between growers and over time, however marketing is one method for managing these risks.

**Production risk** is separated into quantity (yield and area) and quality. With the ability to enter into forward contracts before the crop is planted, there is uncertainty with both the area to be planted (due to seasonal conditions) and the yield that will be achieved. Yield risk also exists when a contract is entered into after planting, but before harvest.

Variable yields may result in a grower under or over producing against contracted commitments. If production exceeds commitments made and the contract price is higher than the spot or market cotton price, then the grower has an opportunity loss. If the grower under produced a fixed bale contract, then the grower may be obligated to fill the contract at market rates, which could result in a financial loss to the grower.

Varying quality is managed by merchants with all forward contracts priced on 'base grade'. Once the cotton is ginned and classed, the final price paid to the grower is adjusted with a premium when the grade is higher than 'base', or a discount in price when the grade is inferior. These pricing adjustments can be found on a merchants corresponding premium and discount sheet (for more information about quality see Classing Chapter 22).

**Price risk** in relation to a cotton grower is when all or a portion of the crop is not priced and the value is reduced due to decreases in the cotton price. Price variability is due to fluctuations in the three components of the Australian dollar cash price:

- ICE cotton futures;
- Basis; and,
- The AUD / USD exchange rate.

Cotton is internationally traded and priced in USD, using the Intercontinental exchange (ICE) Cotton No2 contract (previously managed by the New York Board of Trade).

Basis can be broadly defined as the difference in value (or price) between a physical bale and the futures contract price. Basis accounts for location, grade and local supply and demand conditions.



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Australian growers generally receive their income in Australian dollars, so the USD price is converted into local currency using the AUD/USD exchange rate. This may not be the spot exchange rate, rather the relevant forward rate for any forward contracts.

$$\text{AUD cash price per bale} = \frac{\text{Top Line: USD per bale price} \times \text{Converts price from pounds to bales} \times 500 \text{ lbs}}{\text{AUD/USD exchange rate}}$$

$$\text{eg AU\$500/bale} = \frac{(0.82 - 0.01) \times 500}{0.81}$$

*Converts price from USD/bale to AUD/bale*

All three price elements can and do change on a daily basis. The price of cotton in Australian dollar terms is therefore subject to daily volatility. The major merchants in Australia publish their daily prices on-line or communicate their prices via fax, e-mail and text message. To be kept up to date with pricing movements contact the merchants and ask to be added to their daily price lists.

## Marketing options

Australian cotton growers are well serviced by several cotton merchants who buy cotton from growers to sell in the international market. Due to the relatively small size of the Australian cotton market, it is often the cotton merchants approaching growers to buy cotton, thus creating a price competitive market.

Merchants involved in the cotton market tend to build robust relationships with clients and may contract cotton with these growers up to 4 years into the future, using forward contracts. A forward cotton contract is a customised agreement between two parties to deliver cotton on an agreed future date for an agreed price. Price will be determined in reference to the other terms of the contract – quality, quantity, and the time and place of delivery or the buyer may require a guarantee of a specific grade or quality of the commodity from the seller. From a grower's perspective this may mean selling the cotton before it has been harvested or even planted.

The most commonly utilised forward marketing options are:

**AUD Fixed cash price:** is a forward contract for delivery after ginning of the season specified (i.e 2010–11). Growers accept a certain fixed price and a fixed number of bales are agreed upon in the contract; thus, there is a fixed commitment to deliver.

**Fixed bale pool:** a commitment to deliver a specified number of bales to a 'pool' of bales with a particular marketing organisation. Both price risk and yield risk are borne by the grower, but the price risk is managed by the marketing organisation. Most pools have an indicative price attached and often once that price is no longer achievable, the pool will be closed. As with all pools, payment is spread over a period of time as delivery of cotton from growers, and sales to mills proceed.

**Other pools** may be offered by merchants with varying conditions. Some characteristics of a pool (or other customised contract) may include;

**Hectare contract** where the grower commits a particular acreage, all cotton produced from that area is covered by the contract. The contract may have a maximum yield deliverable to it (eg up to 10 bales/ha). Downside yield risk is managed by the merchant.

Some pool contracts may have a **guaranteed minimum price (GMP)**, with potential (but limited) upside. For these contracts the grower bears production risk and some price risk. Due to the hedging requirements for the merchant to guarantee a certain minimum return, these contracts usually come at a discount to the cash market.

**Balance of crop (BOC)** is a contract where the grower commits their remaining unpriced bales. These contracts are generally available towards the end of the season when the grower can make a reasonable estimate of their yield.

**Force majeure (FM)** 'compelling force, unavoidable circumstances'. When an FM clause is attached to a cotton contract it generally means that a production shortfall in the nominated bales set out in the contract need not be delivered. This variation is borne by the merchant.

## Cotton seed

The value of cotton seed also makes up a significant component of the income from a cotton crop. Cotton seed is priced through the ginning company which may not be the same merchant the cotton is sold through. Cotton seed is priced in bales (based on the amount of seed that is produced in the ginning process of one bale, this is approximately 300kg of seed). Cotton seed has been worth up to \$120/bale, however a price closer to \$60/bale has been more common. The ginning organisation may quote the seed price as 'ginning plus seed' (i.e \$60/bale, may be quoted 'ginning plus \$5/bale', indicating that the seed price covers the ginning price of \$55/bale, with \$5 paid back to the grower). Talk to your preferred ginning organisation about current cotton seed pricing.

For further information on marketing your cotton talk to a merchant or you can find comprehensive marketing notes on the following websites:

**Australian Cotton Shippers Association:**  
<http://www.austcottonshippers.com.au/downloads/GrowerMarketingRiskHandbook.pdf>

**Cotton CRC:**  
[http://www.cottoncrc.org.au/content/Industry/Publications/Economics/Cotton\\_Price\\_and\\_Marketing.aspx](http://www.cottoncrc.org.au/content/Industry/Publications/Economics/Cotton_Price_and_Marketing.aspx)



# Ginning

By **MICHAEL BANGE, CSIRO**

**Acknowledgements:** Greg Constable, Stuart Gordon, Robert Long, Geoff Naylor and Rene van der Sluijs (CSIRO)



The ginning industry in Australia is relatively modern, with higher throughput gins compared with other countries. The principal function of the cotton gin is to separate lint from seed and produce the highest total monetary return for the resulting lint and seed, under prevailing marketing conditions.

Current marketing quality standards most often reward cleaner cotton and a certain traditional appearance of the lint.

**TABLE 1.**

Summary of key post harvest decisions for optimising fibre quality.

| Objectives                     | At the Gin                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Maintaining fibre length       | In the gin, fibre length can be preserved and short fibre contents reduced, by reducing the number of lint cleaner passages (depending on quality of seed cotton) and ensuring fibre moisture at the gin and lint cleaner should be closer to 7% than 5%; however, fibre moisture at either point should not exceed 7%. Lower combing ratios between feed rollers and the saw of lint cleaners also reduces the amount of fibre breakage.      |
| Reducing the incidence of neps | Lint cleaners are responsible for most of the neps found in baled cotton. Reducing the number of lint cleaners reduces neps. Maintenance of prescribed setting distances, e.g. feed and grid bar distances to the lint cleaner saw reduces fibre loss and nep creation, as does close and proper setting of the doffing brush to the saw. Preservation of fibre moisture as prescribed for length preservation also helps reduce nep creation. |
| Preventing contamination       | Clean gravelled module storage yards. Frequent inspection of tarps on modules. Appropriate bale covering/wrap. Storage and handling to avoid country damage.                                                                                                                                                                                                                                                                                   |

## BE AWARE OF

- The main concerns during the ginning process are to maintain quality, optimise lint yield and contain the costs of ginning.
- Appropriate ginning and handling practices post-harvest are important to maximise returns for growers and maintain the industry's reputation for high quality cotton.
- Good communication between growers and ginners is a key factor in assisting this process (see Table 1).

A ginner has two objectives:

1. To produce lint of satisfactory quality for the grower's classing and market system; and,
2. To gin the cotton with minimum reduction in fibre spinning quality so the cotton will meet the demands of its ultimate users, the spinner and the consumer. The spinner would prefer fibre without trash, neps and short fibres. Unfortunately, the highly mechanised (and productive) harvesting and ginning processes used today, mean that removing trash is difficult without introducing some neps and increasing short fibre content.

The challenge for the ginner is therefore to balance the amount of cotton produced (turn-out), the speed at which it is ginned and the effects that the various cleaning and ginning components have on the fibre quality. Particular settings in a gin for speed or heat can exacerbate nep and short fibre content. The use of lint cleaners, while removing trash, also increases the number of neps and short fibres. Whilst not included in existing classification systems for cotton, the presence of neps and short fibre seriously affect the marketing ability. The ginner must also consider the weight loss that occurs in the various cleaning machines. Often the weight loss to achieve higher grade results in greater removal of lint as well, which results in a lower total monetary return to growers and ginners as they are both paid on a per bale basis.

Cotton quality after ginning is a function of the initial quality of the cotton, and the degree of cleaning and drying it receives during ginning; the exact balance between turnout and grade will depend upon the particular premium-and-discount (P&D) sheet applied to the cotton in question. For every P&D sheet there will be a point in the balance between turn-out and grade that maximises the return to the grower.

Given this need to balance competing considerations, it is essential that growers seek to:

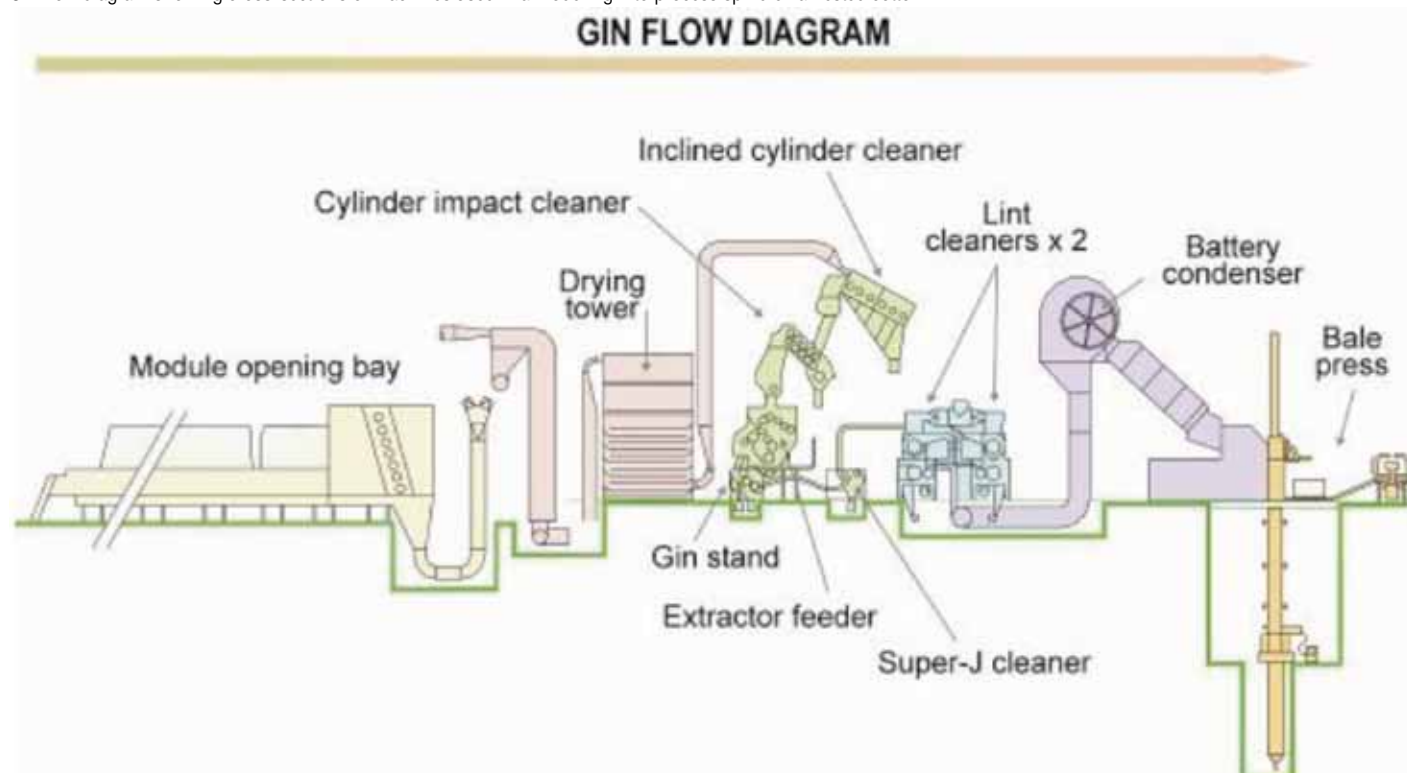
- Ensure defoliation and harvest practices limit trash;
- Contamination is limited; and,
- The size and moisture of the module are appropriate.

Ultimately it is important that growers communicate with ginners these aspects of their harvest prior to the start of the ginning season. An understanding of the issues that were faced in the field may give the ginner insights on how the cotton can be handled to optimise turn-out and quality together.

Modern gins are highly automated and productive systems that incorporate many processing stages. Gins must be equipped to remove large percentages of plant matter from the cotton that would significantly reduce the value of the ginned lint, according to the classing grade standards. Figure 1 shows the cross-section of a gin with machines that are typical of those found in a modern gin, although it is noted that most Australian gins typically have more pre-cleaning stages. This gives them the flexibility to process both spindle harvested cotton and stripper harvested, which requires more pre-cleaning.

**FIGURE 1.**

Gin flow diagram showing cross-sections of machines used in a modern gin to process spindle harvested cotton.



At ginning the lint is separated from the seed. Moisture can be added to dry cotton prior to the gin stand at either the pre-cleaning stage or after the conveyor distributor above the gin stand. However, in Australia the moisture addition at these points is not common. After ginning, fibre travels by air to one or two lint cleaners for further cleaning and preparation. At the lint cleaners moisture content is critical to prevent cotton from significant damage (neps and short fibres). Cotton that is too dry (< 5.5% moisture content) will be damaged to a greater degree during the lint cleaning process.

Chapter 13 of FIBREpak gives more detail on the processes in; the module bay, pre-cleaning, drying and moisture restoration, ginning, lint cleaning and bale moisture restoration.

**This information has been adapted from FIBREpak chapter 13 – post harvest management.**

**Further information:**

**FIBREpak –** [http://www.cottoncrc.org.au/content/Industry/Publications/Fibre\\_Quality/FIBREpak.aspx](http://www.cottoncrc.org.au/content/Industry/Publications/Fibre_Quality/FIBREpak.aspx)





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# Classing

By **JANINE POWELL**

Acknowledgements: Robert Baird, Queensland Cotton; John Stanley, Cotton Production Course, UNE; Helen Dugdale, CRDC



The quality of cotton can be expressed by a number of different measurements which are performed by cotton classers. These measurements are described in a wide range of grades (Table 1), and affect the final price that is paid for a bale of cotton.

Once cotton is ginned, and while it is being baled, a sample (of at least 120g) is taken from both sides of every bale and bulked together and sent to the specialist classers.

Historically, the cotton industry has employed both visual and mechanical methods to determine quality. Most aspects of visual cotton classing are gradually being replaced by the HVI (High Volume Instrument) system which determines most quality specifications by instrument.

Visual methods based on definite and specific grades

## BE AWARE OF

- Classing is a complex process, whilst this chapter gives an overview, a more detailed understanding can be gained from visiting your nearest classing facility.

established by the United States Department of Agriculture (USDA) for upland cotton determine the differing qualities and describe cotton for buying and selling when samples are not available. Cotton classers are skilled in determining those grades visually, but now also use HVI systems. A classer's grade is colour, leaf and preparation.

The price received for cotton is dependent on the quality of each bale of cotton. Cotton prices are quoted for 'base grade' 31-3-36, G5 (see Figure 1). Premiums and discounts apply for higher and lower grades respectively. These pricing adjustments reflect the change in suitability for the spinning and dyeing process (see Chapter 7, Table 1, page 31 'Consequences of poor fibre quality' right column). For this reason, variability in any quality characteristic may influence the price. Some of the key quality characteristics are outlined below:

- Colour
- Leaf
- Staple length
- Micronaire
- Strength
- Preparation

## Colour

The colour of a sample is currently measured visually by a trained cotton classer. The true colour can only be assessed under specific light conditions and via comparison to a 'standard' sample of universal standards provided by the USDA.

The colour grade considers how bright or dull a sample is and the degree of colour pigmentation from white through to spotted and to yellow stained. A colour of 31 is Australian base grade.

**FIGURE 1.**  
Interpretation of Base Grade: 31-3-36, G5

| BASE GRADE: 31             |          | 3              |      | 36,            |           | G5                     |           |
|----------------------------|----------|----------------|------|----------------|-----------|------------------------|-----------|
| Colour                     |          | Leaf           |      | Staple Length, |           | Micronaire             |           |
| Descriptor                 | Code     | Descriptor     | Code | Measurement    | Code      | Measurement            | Code      |
| Good Middling (GM)         | 1        | White          | 1    | 1 inch         | 32        | 2.4 and below          | G0        |
| Strict Middling (SM)       | 2        | Light Spotted  | 2    | 1 1/32"        | 33        | 2.5 through 2.6        | G1        |
| <b>Middling (MID)</b>      | <b>3</b> | Spotted        | 3    | 1 1/16"        | 34        | 2.7 through 2.9        | G2        |
| Strict Low Middling (SLM)  | 4        | Tinged         | 4    | 1 3/32"        | 35        | 3.0 through 3.2        | G3        |
| Low Middling (LM)          | 5        | Yellow Stained | 5    | <b>1 1/8"</b>  | <b>36</b> | 3.3 through 3.4        | G4        |
| Strict Good Ordinary (SGO) | 6        |                |      | 1 5/32"        | 37        | <b>3.5 through 4.9</b> | <b>G5</b> |
| Good Ordinary (GO)         | 7        |                |      | 1 3/16"        | 38        | 5.0 through 5.2        | G6        |
| Below Grade (BG)           | 8        |                |      | 1 7/32"        | 39        | 5.3 and above          | G7        |

Actual length applies so this table is just an example of possible staple lengths



## Leaf

Also known as 'trash' is a measure of the amount of leaf material (from the cotton plant) remaining in the cotton sample. While the gin removes the majority of trash, some remains in the sample. The remaining trash is removed in the spinning process which reduces lint yield and increases cost. So cotton with high levels of trash attracts a discount. Leaf grades range from 1 (lowest) to 5 (highest), with level 3 as 'base grade'.

## Staple length

Length is measured on a sample of fibres known as a 'pull' when hand classing, and is measured to the nearest 1/32 inch. HVI determine length in 100ths of an inch or on a 'beard' or tuft of lint formed by grasping fibres with a clamp. Australian cotton is all classed using HVI measurements. Under raingrown conditions, staple length tends to range from similar to irrigated cotton (1 1/8 inches) down to very short (1 inch or less). Base grade is 36 or (1 1/8").

## Micronaire

Micronaire is measured by placing lint in a chamber, compressing it to a set volume and subjecting it to a set pressure. The reading, when related to a variety, it is an approximate guide to fibre thickness and has been used as a measure of fibre maturity. Other, more accurate, fibre maturity testing methods and devices are being tested

and may soon be introduced but for now the general guidelines below still apply:

- Low (<3.5) micronaire indicates fine (immature) lint.
- High (>4.9) micronaire indicates coarse lint.

The desired range is 3.5 to 4.9 (G5) and discounts apply for micronaires outside that range. Discounts for low micronaire can be heavy.

Common causes of low micronaire include:

- Cool temperatures during fibre wall development;
- Potassium deficiency;
- Dense plant stands;
- High nitrogen;
- Excess irrigation / rainfall;
- Favourable fruit set and high boll retention; and,
- Early cut-out due to frost, hail, disease or early defoliation.

The most common causes of high micronaire include:

- Poor boll set;
- Small boll size due to hot weather or water stress; and,
- Variety.

Ginning has little or no effect on micronaire although low micronaire cotton is more susceptible to entanglement and nepping which can affect preparation and subsequently grade.

Raingrown cotton normally falls into the acceptable micronaire range, but under hot, dry conditions some

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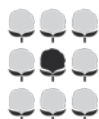
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varieties are prone to produce high micronaire. Late planted crops are susceptible to low micronaire and heavy discounts sometimes apply.

Management practices that open immature bolls such as pre-mature defoliation can contribute to the inclusion of immature fibres and an increase in neps. Experiments conducted at the Australian Cotton Research Institute confirmed that defoliating before 60% bolls open lowers micronaire (reduced fibre maturity) and increases neps.

## Fibre strength

Fibre strength is highly dependent on variety although environmental conditions can have a small effect. Raingrown cotton strength is usually not adversely affected by growing conditions. Most Australian varieties are of high strength and local plant breeders have agreed to eliminate varieties that do not meet a minimum standard, thus keeping Australian cotton highly competitive in the world market. Fibre strength is measured by clamping a bundle of fibres between a pair of jaws and increasing the separation force until the bundle breaks.

Strength is expressed in terms of grams force per tex with the following classifications:

- Less than 17 very weak;
- 18 – 21 weak;
- 22 – 25 medium strong;
- 26 – 29 strong (most current Australian varieties); and,
- More than 30 very strong.

## Preparation

Preparation (often referred to as 'prep') relates to the evenness and orientation of the lint in the sample. Factors contributing to poor preparation include spindle twist or wrapping during picking or roping or knotting (neps) of immature or very fine fibres in the ginning process.

## Other quality characteristics

Pricing adjustments (premiums or discounts) may be made for other undesirable quality characteristics including (but not limited to):

- Grass or bark in the sample;
- An un-uniform sample;
- Sugars (honeydew);
- Neps; and,
- Short Fibre (below 32).

A number of other fibre characteristics measured in HVI testing which, whilst of increasing importance to spinners, do not have a direct impact on price at present include:

- Upper Half Mean Length (UHML);
- Span Length;
- Uniformity Ratio (UR);
- Elongation (EL);
- Short Fibre Index (SFI);
- Maturity; and,
- Fineness.

## Cotton grade and price

The price received for cotton is dependent on the quality of each bale. Cotton prices are quoted for 'base grade' 31-3-36, G5. Premiums and discounts apply for higher and lower grades respectively.

Cotton merchants generally present actual classing results in an easy to read report displaying the AUD \$/bale premiums or discounts.

These pricing adjustments are calculated using their 'Premiums and Discount (P&D) Schedules' or 'Differential Sheets'. Australian merchants P&D schedules are formatted similarly and the adjustments are generally quite similar, but there may be some differences. P&D schedules often change between seasons and sometimes within the season – the merchant will generally set the season's P&D around ginning time. From this time they can be requested from your merchant.

Premiums or discounts may be displayed in either USD \$/lb or USD points/lb. There is 100 points in a cent. For example a 300 point discount is equivalent to -\$0.03. To convert from per pound to per bale, multiply by 500. To convert into Australian dollars, divide by the USD/AUD exchange rate (ask your merchant the exact exchange rate which is applicable).

For example: A total discount of 800pts/lb

|   |                   |
|---|-------------------|
| = | -\$0.08/lb        |
| = | -\$0.08 x 500     |
|   | .85               |
| = | AUD -\$47.06/bale |

Multiple adjustments may apply to one bale of cotton. There is one adjustment for colour – leaf – staple length, while all other characteristics have their own adjustments

**For more information talk to your merchant, their classing facility or look at the following websites:**

**FIBREpak:** [http://www.cottoncrc.org.au/content/Industry/Publications/Fibre\\_Quality/FIBREpak.aspx](http://www.cottoncrc.org.au/content/Industry/Publications/Fibre_Quality/FIBREpak.aspx)

**Australian Cotton Shippers association:**  
<http://www.austcottonshippers.com.au/>

**Cotton Classers Association of Australia contact Greg Parle, Auscott Ltd,**  
**Ph: 02 9439 0514**





# Glossary & acronyms

## Glossary

**Alluvium** refers to sediment that has been deposited by flowing water, such as a flood plain.

**Aphid colony** 4 or more aphids within 2cm on a leaf or terminal.

**Area Wide Management (AWM)** Growers working together in a region to manage pest populations. AWM is a cotton industry vehicle driving adoption of on-farm IPM.

**At-planting insecticide** Insecticides applied in the seed furrow with the seed during planting. The insecticide may be applied as a granule or as a spray into the seed furrow.

**Australian Rainman StreamFlow** A computer program for PC/Windows which analyses rainfall information and can forecast seasonal rainfall.

**BDI Beneficial Disruption Index** The sum of scores for the entire cotton season of the impact of each insecticide on beneficial insect populations. The BDI helps benchmark the 'softness' or 'hardness' of an individual fields' insecticide spray regime.

**Beat sheet** A sheet of yellow canvas 1.5 m x 2 m in size, placed in the furrow and extended up and over the adjacent row of cotton. A metre stick is used to beat the plants against the beat sheet. Insects are dislodged from the plants onto the canvas and are quickly counted.

**Beneficial Disruption Index (BDI)** Is a score for each insecticide based on the overall impact of the insecticide on beneficial insect populations.

**Beneficial insects** Predators and parasitoids of pests.

**Biological insecticides** Insecticides based on living entomopathogenic (infecting insects) organisms, usually bacteria, fungi or viruses, or containing entomopathogenic products from such organisms i.e. Gemstar, Vivus and Dipel (BT).

**Biomass** Plant biomass is the total dry weight of the crop.

**Boll** Cotton fruit after the flower has opened and fertilisation has occurred (after the flower has turned pink). Bolls typically have four or five segments, known as locks, each containing about 6 – 10 seeds. The lint, or cotton fibre, is produced by elongated cells that grow from the surface of the seed coat, hence the 'seed cotton' in the boll is a mixture of seed and lint.

**Bollgard II® cotton** Genetically modified cotton variety containing the insecticidal proteins Cry1Ac and Cry2Ab which provides control of *Helicoverpa* spp., rough bollworm, cotton tipworm and cotton looper under field conditions.

**Broad spectrum insecticide** Insecticides that kill a wide range of insects, including both pest and beneficial species. Use of broad spectrum insecticides usually reduces numbers of beneficials (predators and parasites) leading to pest resurgence (see below) and outbreaks of secondary pests.

**Bt** The *Bacillus Thuringiensis* protein which is toxic to *Helicoverpa* spp.

**Buffer zone** A boundary of land or crop set up within or outside the cotton farm to collect spray droplets that may otherwise drift onto sensitive areas, such as rivers or pasture.

**Calendar sprays** Insecticides sprayed on a calendar basis, e.g. every Friday, regardless of pest density or the actual need for pest control.

**Cold shock** Is when the daily minimum temperatures fall below 11°C. When this occurs, cotton growth and development the following day can be reduced regardless of the maximum temperature reached. Cold shocks have greatest impact on early plant development and will delay the timing of emergence, squaring and flowering and increase the susceptibility of plants to diseases.

**Consecutive checks** Refers to successive insect checks taken from the same field or management unit.

**Conventional cotton** Strictly a cotton variety that does not contain transgenes (genes from other species), but used in this guide to indicate varieties that do not include genes to produce insecticidal proteins (i.e. Bollgard II®) but which may include herbicide resistance genes (i.e. Round-up Ready®).

**CottASSIST** A group of web tools developed by CSIRO, Cotton CRC and CRDC designed to deliver the latest cotton research and integrate up-to-date information and assist with cotton management decisions.

**Cotton bunchy top (CBT)** A relatively new disease spread by the cotton aphid (*Aphis gossypii*, Glover). Symptoms of CBT include reduced plant height, leaf surface area, petiole length and internode length. Pale angular mottling of the leaf margins is the most reliable diagnostic feature.

**Cotyledons** Paired first leaves that emerge from the soil when the seed germinates.

**Crazy cotton** Multi-branched cotton caused by excessive and repeated tipping out.

**Crop compensation** The capacity for a cotton plant to 'catch-up' after insect damage without affecting yield or maturity.

**Crop Development Tool** A web tool which allows crop managers to monitor both vegetative and reproductive growth of their crops compared to potential rates of development.

**Crop maturity** This usually occurs when 60–65% of bolls are mature and open. Cotton bolls are mature when the fibre is well developed, the seeds are firm and the seed coats are turning brown in colour.

**Cut-out** As the cotton plant continues to develop bolls, the demand for carbohydrates that are produced in the leaves increases. Eventually the demand by the bolls exceeds supply, resulting in the production of new fruiting nodes ceasing and the shedding of excess bolls, less than 14 days old. This point is known as 'cut-out'. An approximation of the timing of cutout is when a crop has reached on average 4 nodes above white flower (NAWF).

**Damage threshold** The level of damage from which the crop will not recover completely and which will cause some economic loss of yield or delay in maturity. Damage thresholds are usually applied in conjunction with pest thresholds to account for both pest numbers and plant growth. For instance a plant which has very high fruit retention (see below) may be able to tolerate a higher pest threshold (see below) than a crop with poor fruit retention.

**Day degrees (DD)** A unit combining temperature and time, useful for monitoring and comparing crop development. To calculate your DD visit the Australian Cotton CRC website.

**Deep drainage** Water from rainfall or irrigation that has drained below the root zone of the crop. A certain amount of deep drainage helps flush salts from the soil, but excess deep drainage means water and nutrients are being wasted.

**Defoliation** The removal of leaves from the cotton plant in preparation for harvest. This is done by artificially enhancing the natural process of senescence and abscission with the use of specific chemicals.

**Denitrification** A biological process encouraged by high soil temperatures. Denitrification occurs when there is waterlogging, such as during and after flood irrigation and/or heavy rainfall sufficient. The process converts plant available N (nitrate) back to nitrogen gases which are lost from the system.

**Dessicant** A chemical used as a harvest aid that damages the leaf membrane causing loss of moisture in the leaf producing a desiccated leaf.

**Determinate/indeterminate** Cotton is an indeterminate species which is capable of continuing to grow after a period of stress. Although short season varieties are considered determinate, which terminate reproductive development comparatively abruptly.

**Diapause** A period of physiologically controlled dormancy in insects. For *Helicoverpa armigera*, diapause occurs as the pupal stage in the soil.

**Doffer** Doffers unwind and remove the cotton from the spindle so that it can be transported to the basket in an airstream.

**Double knock** Is the sequential application of two weed control options where the second option is designed to control the Double Skip A row configuration used in dryland/Semi irrigated situations to conserve soil moisture.



**D-Vac** A small portable suction sampler or blower/vacuum machine used to suck insects from the cotton plants into a fine mesh bag. D-vac samples are collected by passing the tube of the vacuum sampler across the plants in 20 m of row. When plants are small this may be a single pass, but when plants are bigger a zig zag pattern from the bottom to the top of the crop with each step of the operator may be required to sample the canopy more effectively. Samples from the d-vac bag are transferred into a plastic bag and counted.

**Earliness** Minimising the number of days between sowing and crop maturity. Within a cotton variety earliness usually involves some sacrifice of yield.

**Early season diagnostic (ESD) tool** A web-based tool to graph and display day degrees and node counts against a theoretical optimum crop development rate to determine where the crop development is at compared with where it should be.

**Efficacy** The effectiveness of a product against pests or beneficial insects (predators or parasites).

**Egg parasitoids** They are parasitoids that specifically attack insect eggs. E.g. *Trichogramma pretiosum* attacks the egg stage of *Helicoverpa*. The wasp lays its eggs in the egg, and the wasp larvae which hatch consume the contents of the host egg. Instead of a small *Helicoverpa* larva hatching, up to four wasps may emerge from each host egg. Thus the host is killed before causing damage.

**Flat fan nozzle** A spray nozzle with an outlet that produces spray droplet distribution that spreads out of the nozzle in one direction but which is thin in the other direction, much like the shape of a Chinese or Japanese hand fan.

**Flush** A high volume irrigation carried out in minimal time.

**Food sprays** They are natural food products sprayed onto cotton crops to attract and hold beneficial insects, particularly predators, in cotton crops so they can help control pests. Two types of food sprays are available for pest management. They are the yeast based food sprays which attract beneficial insects and the sugar based ones which retain predators which are already in the crop.

**F Rank** A rank that each cotton variety is given in accordance with its resistance to the cotton disease Fusarium Wilt.

**Fruit load** Refers to the number of fruit (squares or bolls) on a cotton plant.

**Fruit retention** Refers to the percentage of fruit (squares or bolls) that the cotton plant or crop has maintained compared with number it produced.

**Fruiting branch** Grows laterally from the main stem in a series of segments. Each segment finishes at a node at which there is a square and a leaf. At the base of the square next segment originates, and so on.

**Fruiting factor** Is a measure of the number of fruit per fruiting branch. A method to check if the total fruit number produced by the crop is on track. Fruiting factors which are too high or too low can indicate problems with agronomy or pest management which may need to be acted on. To calculate the fruiting factor divide the fruit count made in 1 metre of cotton row by the number of fruiting branches in that area.

**Gilgai micro relief** is formed due to clay horizons shrinking and swelling with alternate drying and wetting cycles. This forces 'blocks' of subsoil material gradually upwards to form mounds.

**Habitat diversity** A mixture of crops, trees and natural vegetation on the farm rather than just limited or single crop type (monoculture).

**Hill** Refers to the risen bed where the crop is planted in a furrow irrigated field.

**Honeydew** A sticky sugar rich waste excreted by feeding aphids or whiteflies. It can interfere with photosynthesis, affect fibre quality and cause problems with fibre processing.

**HVI – High Volume Instrument** Is an instrument that is able to quickly and accurately determine the fibre properties of a large volume of cotton.

**HydroLOGIC** Irrigation management software, available through CottASSIST which can be accessed via the Cotton CRC web site.

**Irrigation deficit** Readily available water capacity.

**In-furrow insecticide** Insecticides applied in the seed furrow with the seed during planting. The insecticide may be applied as a granule or as a spray into the seed furrow.

**Insecticide resistance** Where a pest develops resistance to an

insecticide, the insecticide will no longer kill those individuals that are resistant. This usually results in poor control and may lead to failure of control with the insecticide in the worst cases. The resistant insects develop a mechanism for dealing with the insecticide, such as production of enzymes which break the insecticide down quickly before it kills the pest.

**Insecticide Resistance Management Strategy (IRMS)** An industry regulated strategy that sets limits on which insecticides can be used, when they can be used and how many times they can be used. This helps prevent the development of insecticide resistance.

**Labile P/non-labile P** There are a few Phosphorus fractions within the soil including labile (available) P and non-labile (slow release) P.

**Lay-by herbicide** A residual herbicide used to control weeds in-crop or during the growth of the cotton crop.

**Larval parasitoids** A wasp that lays their egg on or in a larva and use the lifecycle of the larva in order to reproduce. Parasitoids usually cause the death of their host whereas parasites do not.

**Leaf crumpling** Leaves that are wrinkled, cupped and smaller than normal. This can be caused by thrips.

**Lint cotton fibres** These are elongated cells growing from the surface of the cotton seed coat. See also 'Bolls'.

**Listing rig** A cultivator used to form cotton beds.

**Lodging** Towards the end of the season cotton plants with large and heavy boll loads will often fall into each other which is known as lodging.

**Main stem node** A point on the main stem from which a new leaf grows. At these points there may also be fruiting or vegetative branches produced.

**Management unit** An area on the farm that is managed in the same way i.e. same variety, sowing date, insect management.

**Micronaire** Measurement of specific surface area based on the pressure difference obtained when air is passed through a plug of cotton fibres. This reflects fineness and maturity.

**Mycorrhiza** Specialised fungi which form beneficial associations with plant roots and can act as an agent for nutrient exchange.

**NACB** The number of main stem Nodes Above the first position Cracked Boll. This is an indication of the maturity of the plant and can be used in making decisions about the final for irrigation or defoliation.

**Natural enemies** Predators and parasitoids of pests.

**Natural mortality** The expected death rate of insects in the field mainly due to climatic and other environmental factors including natural enemies.

**NAWF** The number of main stem Nodes Above the first position White Flower that is closest to the plant terminal.

**Neutron probe** An instrument used to measure soil moisture.

**Node** A leaf bearing joint of a stem, an important character for plant mapping in cotton where nodes refer to the leaves or abscised leaf scars on the main stem.

**Normalised difference vegetation index** Is an indicator used to analyse remote sensing measurements to assess whether the observed target contains live green vegetation.

**Nursery** A crop or vegetational habitat which attracts and sustains an insect (pest or beneficial) through multiple generations.

**NutriLOGIC** Nitrogen fertiliser management software in CottonLOGIC or on the Australian Cotton CRC website.

**NUTRIpak** An information resource for cotton nutrition, including critical levels for soil tests, and interactions between different nutrients.

**Nymph** The immature stage of insects which looks like the adult but without wings. Eg. nymphs of mirids. Nymphs gradually acquire adult form through a series of moults and do not pass through a pupal stage. In contrast, 'larvae' are immature stages of insects, such as the *Helicoverpa* caterpillars, that look quite different to the adults, which in this case is a moth.

**Okra leaf type** Cotton varieties with deeply lobed leaves that look very similar to the leaves on the Okra (*Abelmoschus esculentus*) plant, which is related to cotton and hibiscus.

**OZCOT model** A cotton crop simulation model that will predict cotton growth, yield and maturity given basic weather, agronomic and varietal data.

**Partial root zone drying** The creation of simultaneous wet and dry





areas within the root zone. Only part of the root zone is irrigated and kept moist at any one time.

**Pest flaring** An increase in a pest population following a pesticide application intended to control another species. This usually occurs with species that have very fast life cycles such as spider mites, aphids or whitefly. It occurs following the use of broader spectrum insecticides which control the target pest but also reduce the numbers of predators and parasites. This allows these 'secondary' or non-target pests to increase unchecked, often reaching damaging levels and requiring control.

**Peak flowering** The period of crop development where the plant has the highest numbers of flowers opening per day.

**Pest damage** Damage to the cotton plant caused by pests. This can be either damage to the growing terminals (known as tipping out), the leaves, or the fruit (including squares or bolls).

**Pest resurgence** An increase in a pest population following a pesticide application intended to reduce it. This usually occurs because the insecticide has reduced the numbers of beneficials, which normally help control the pest, thereby allowing subsequent generations of the pest to increase without this source of control.

**Pest threshold** The level of pest population at which a pesticide or other control measure is needed to prevent eventual economic loss to the crop. See also 'Damage threshold'.

**Petiole** The stalk that attaches the leaf to the stem.

**Phase 1** The period between planting and the start of flowering (one flower per metre).

**Phase 2** The period between flowering to first open boll.

**Phase 3** The period between first open boll to harvest.

**Pima cotton** Normal cotton is of the species *Gossypium hirsutum*, pima is of the *Gossypium barbadense* species. It has an extra long staple and its growth is limited to regions with long growing seasons.

**Pix** Mepiquat chloride cotton growth regulator.

**Plant available water Capacity (PAWC)** The amount of water in the soil that can be extracted by plants, usually full point (when the soil can hold no more water) minus wilting point (point at which the plant can no longer extract sufficient water from the soil and begins to wilt).

**Plant cell density** A term used in precision agriculture which is a ratio of infra-red to red reflectance produced from digital imagery.

**Plant growth regulator** Chemicals which can be applied to the plant to reduce growth rate (see also 'Rank growth').

**Plant mapping** A method used to record the fruiting dynamics of a cotton plant. This can be useful for understanding where the plant has held or is holding the most fruit in order to interpret the effects of factors that may affect fruit load such as pest damage, water stress, heat.

**Plant stand** The number of established cotton plants per metre of row.

**Planting window** Is a period of time in which you need to plant your cotton. Bollgard II® cotton has a planting window which is a strategy used to restrict the number of generations of *Helicoverpa* spp. Exposed to Bollgard II® in a region.

**Plastic limit** The water content where soil starts to exhibit plastic behaviour.

**Post-emergent knockdown herbicide** A herbicide used to rapidly control weeds after they emerge.

**Predator to pest ratio** A ratio used to incorporate the activity of the predatory insects into the pest management decisions. It is calculated as total number of predators per metre divided by the total number of *Helicoverpa* spp. eggs plus very small and small larvae per metre.

**Premature cut-out** Premature cut-out is when the production of bolls exceeds the supply of carbohydrates too early in the crops development and therefore the production of new fruiting nodes stops. This results in a less than ideal boll load.

**Pre-plant knockdown herbicide** A herbicide used to rapidly control weeds prior to planting.

**Presence/absence** The binomial insect sampling technique that records the presence or absence of a pest rather than absolute numbers on plant terminals or leaves, depending on the pest species being sampled.

**Prophylactic** Refers to regular insecticide sprays applied in anticipation of a potential pest problem. Spraying on a prophylactic basis runs the risk of spraying to prevent pest damage that would not have occurred anyway, thereby increasing costs, selection for insecticide resistance and the risk of causing secondary pest outbreaks due to reductions in predator and parasite numbers.

**PSO petroleum spray oil** Are petroleum derived oil commonly used to control insect pests such as *Helicoverpa* spp., mirids, mealy bugs, aphids, thrips, scales and mites. PSOs can also be used to deter egg lay of some pests such as *Helicoverpa* spp.

**Pupae** Once larvae of *Helicoverpa* have progressed through the larval (caterpillar) stages they will move to the soil and burrow below the surface. Here they will change into a pupae (similar to a butterfly chrysalis). In this stage they undergo the change from a caterpillar to a moth.

**Pupae busting** Effective tillage to reduce the survival of the overwintering pupal stage of *Helicoverpa*. Pupae busting is an important tool in reducing the proportion of the *Helicoverpa* population carrying insecticide resistance from one season to the next.

**Rank crop** A rank crop is usually very tall (long internode lengths) with excessive vegetative plant structures. This can be caused by a number of factors including excessive fertiliser use, pest damage and crop responses to ideal growing conditions especially hot weather. Rank crops can be difficult to spray and to harvest and may have delayed maturity or reduced yield. Seed company web sites detail methods to assess plant growth to test if a plant growth regulator might be needed to prevent such rank growth.

**Ratoon cotton** A cotton crop in which the stalks are cut down after harvest, but the crown and rootstock are left in the ground to regrow the following season. For pest and disease reasons, this form of cropping is not used in Australia.

**Refuge** This term is used to refer to crops grown specifically as a requirement of the Bollgard II® licence to produce *Bacillus thuringiensis* (Bt) susceptible *Helicoverpa* spp.

**Rotation crops** Other crop types grown before or after the cotton is grown.

**Scouting** Checking crops (e.g. for insects, damage, weeds, growth etc) survivors of the first tactic.

**Secondary pests** Pests such as spider mites, aphids or whiteflies which do not usually become a problem unless their natural enemies (predators or parasites) are reduced in number by insecticides. See also 'Pest Flaring'.

**Seed bed** A type of mound on which furrow irrigated cotton is grown.

**Seed treatment** An insecticide/ fungicide used to coat cotton seeds to offer a period of protection during germination and establishment against some ground dwelling pests eg. wireworm and some early foliage feeders such as thrips or aphids.

**Selection pressure** The number of times insecticides from a particular chemical group are sprayed onto a cotton crop. Each of these spray events will control susceptible individuals, leaving behind those that are resistant. More selection events means that there is greater 'pressure' or chance of selecting a resistant population.

**Side-dressing** Normally refers to adding an in-crop fertiliser.

**Single skip** A row configuration used in dryland/ Semi irrigated situations to conserve soil moisture.

**Sodicity** A measure of exchangeable sodium in relation to other exchangeable cations. A sodic soil contains sufficient exchangeable sodium to interfere with the growth of plants.

**'Soft' approach** Managing insect and mite pests using pesticides and other approaches that have limited effect on beneficial insect populations.

**SOILpak** Information about cotton soils.

**Soil water deficit** The difference between a full soil moisture profile and the current soil moisture level.

**Solid plant** A row configuration generally used in irrigated cropping and is normally 1m row spacing.

**Solodic soils** Are typical in semi-arid and subhumid climatic zones and tend to be very dense soils with low permeability. The difference between solodic soils and solodized solonetz soils occurs in the structure of the B horizon: solodics have a medium to coarse blocky structure whereas solodized solonetz soils have a coarse columnar structure with clearly defined domes on the tops of the columns.

**Spray adjuvant** A substance added to the spray tank that will improve the performance of the chemical.

**Spring tickle** Uses shallow cultivation to promote early germination of weeds prior to sowing. These weeds can then be controlled with a non-selective knockdown herbicide.



**Square** Cotton flower bud.

**Squaring nodes** A node at which a fruiting branch is produced, which is defined as a branch with a square which has a subtending leaf that is fully unfurled and on which all central veins are visible.

**Standing stubble** Stalks from a crop that has been harvested or sprayed out and left to stand in the field.

**Subbing up** An irrigation term referring to the wetting process of the cotton beds.

**Sucking pests** Pest, usually from the group of insects known as hemiptera or bugs which have piecing tubular mouthparts which they insert into plant parts to obtain nutrition. Key among these are green mirids, which feed on cotton terminals, and young squares and bolls. Some bugs inject toxins into the plant when they feed, which if bolls are fed on may cause seed damage and staining of lint.

**Sweep net** A large cloth net (approximately 60cm deep) attached to a round aluminium frame which is about 40cm in diameter with a handle (1 m in length) used to sample insects.

**Synthetic insecticides** Non-biological insecticides. They may be man made versions of natural insecticides (i.e. pyrethroids are synthetic, light stable versions of naturally occurring pyrethrum) or they may simply be man made molecules with insecticidal or miticidal (controls mites) activity. In this guideline we have used the term to encompass most insecticides with the exception of Bt sprays, virus sprays, food sprays and petroleum spray oils (PSOs).

**Terminal** The growing tip of a cotton stem, particularly the main stem.

**Tip damage** When the plant terminal has been damaged, also known as tipping out.

**Top 5 retention** The percentage of first position fruit maintained on the top 5 fruiting branches.

**Trap crop – last generation** A crop grown to concentrate *Helicoverpa* moths emerging late in the cotton season from the non-diapausing component of pupae from the last generation in autumn. These pupae are likely to be more abundant under conventional cotton and will have had intense insecticide resistance selection. The aim is to have these moths lay their eggs in the trap crop where the resulting pupae can be controlled by cultivation.

**Trap crop – spring** A crop grown to concentrate *Helicoverpa armigera* moths emerging from diapause, usually between September and October. These moths will establish the first generation of larvae in these crops, where they can be killed using biological insecticides (ie. virus sprays) or by cultivation to kill the resulting pupae.

**Trap crop – summer** A crop grown to draw *Helicoverpa armigera* away from a susceptible crop like cotton, and which can also produce large numbers of beneficial insects. The aim is to have these moths lay their eggs in the trap crop where the resulting larvae can be controlled using biological insecticides (i.e. virus) or the pupae controlled by cultivation.

**True leaves** Any leaf produced after the cotyledons.

**VAM Vesicular Arbuscular Mycorrhiza:** A partnership between soil borne fungi and most crop plants, including cotton (but not brassicas). VAM fungi colonise the roots of the plant without causing disease. VAM fungi act as an extension of the root system and transfer extra nutrients, especially phosphorus, from the soil to the plant. In return the plant provides the fungi with sugars as a food source.

**Vegetative growth** The roots, stems and leaves as distinct from the reproductive growth of flowers and bolls.

**Vertisols** Clay-rich soils that shrink and swell with changes in moisture content.

**Visual sampling** Sampling insects in the field with the naked eye without the use of other equipment. See also 'Beat sheets', 'Sweep net' and 'D-vac'.

**V Rank** A rank that each cotton variety is given in accordance with its resistance to the cotton disease Verticillium Wilt.

**Water stress** When the demand for water to maintain plant function exceeds the amount available to the plant from the soil.

**Waterlogging** When the plant roots endure a prolonged period under water, the lack of oxygen impairs water and nutrient uptake, both of which will have a direct effect on growth and yield.

**WATERpak** An information resource for cotton water use and management.

## Acronyms used in the cotton industry

AAAA – Aerial Agricultural Association of Australia

ACIC – Australian Cotton Industry Council

ACPA – Australian Cotton Pickers Association

ACRI – Australian Cotton Research Institute Narrabri

AIRAC – Avcare Insecticides Resistance Action Committee

APSRU – Agricultural Production Systems Research Unit

APVMA – Agricultural Pesticides and Veterinary Medicines Authority

AWM – Area Wide Management

CCA – Crop Consultants Australia Inc.

CCAA – Cotton Classers Association of Australia

CGA – Cotton Growers Association

CA – Cotton Australia

CRDC – Cotton Research & Development Corporation

Cotton CRC – Cotton Catchment Communities Cooperative Research Centre

CSD – Cotton Seed Distributors

CSIRO – Commonwealth Scientific & Industrial Research Organisation

DAFF – Department Agriculture Fisheries and Forestry

EC – Electrical Conductivity

EM Survey – Electromagnetic Survey

EPA – Environmental Protection Authority (NSW/QLD)

ESP – Exchangeable Sodium Percentage

GPS – Global Positioning System

GVB – Green Vegetable Bug

HVI – High Volume Instrument is an instrument that is able to quickly and accurately determine the fibre properties of a large volume of cotton.

ICAC – International Cotton Advisory Committee

ICE – Intercontinental Exchange

IPM – Integrated Pest Management

IRMS – Insecticide Resistance Management Strategy

IWM – Integrated Weed Management

MIS – Multispectral Imaging System

NSW I&I – New South Wales Department of Industries and Investment

OGTR – Office of the Gene Technology Regulator

PAWC – Plant Available Water Capacity

QDEEDI – Queensland Department Employment, Economic Development & Innovation

RCMAC – Raw Cotton Marketing & Advisory Committee

SLW – Silver Leaf Whitefly

TIMS – Transgenic & Insect Management Strategy (Committee)

TRC – Cotton CRC Technology Resource Centre

TSV – Tobacco Streak Virus

ULV – Ultra Low Volume

VGR – Vegetative Growth Rate

WUE – Water Use Efficiency

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