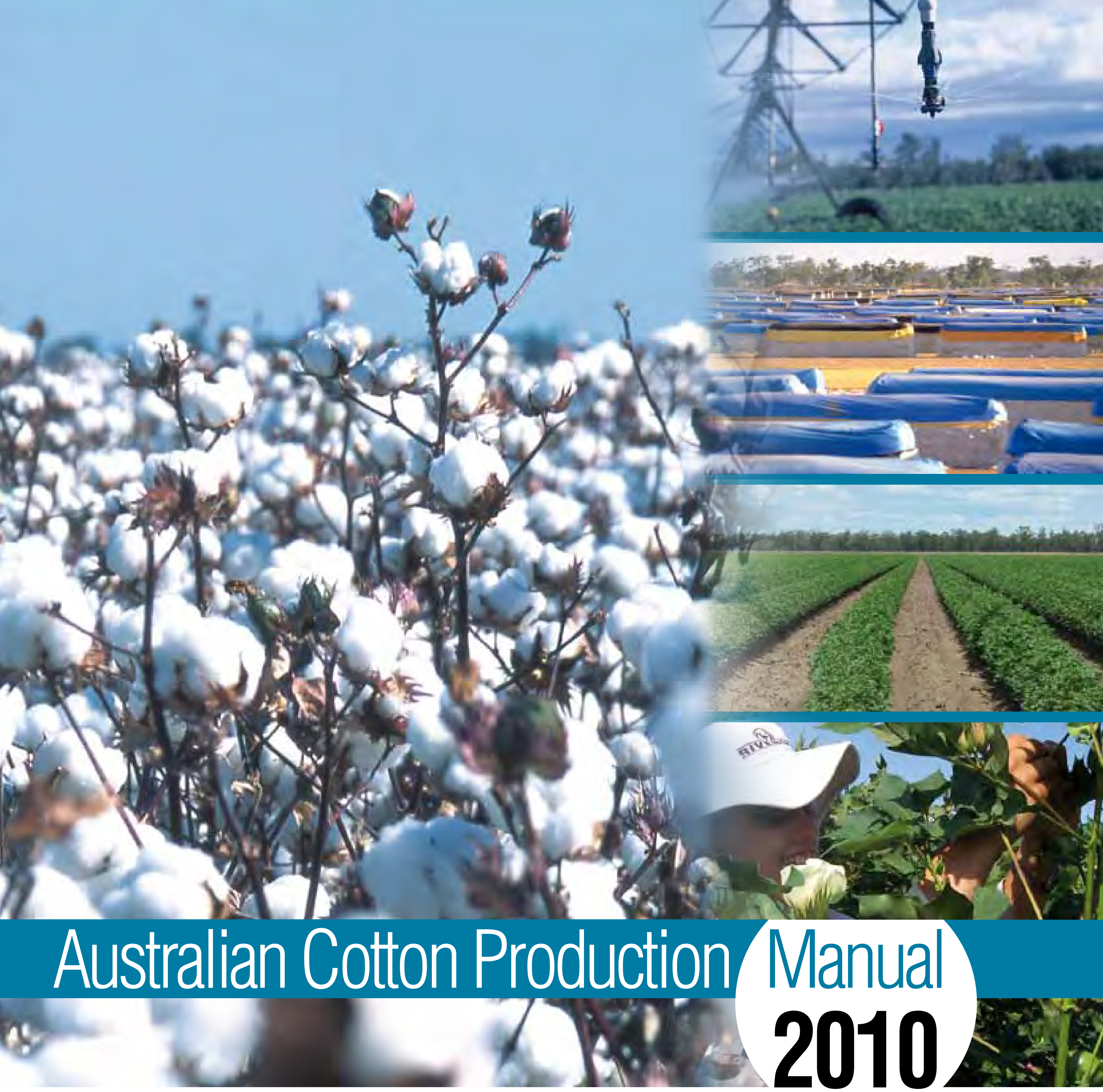

Australian Cotton Production Manual 2010

Cotton CRC Development and Delivery Team

Incorporating
Dryland Cotton Production Guide
and Irrigation Information

Australian Government
Cotton Research and Development Corporation

Cotton Catchment Communities CRC

CSD
Cotton Seed Distributors

Best Practice

Development & Delivery team...

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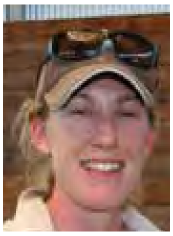

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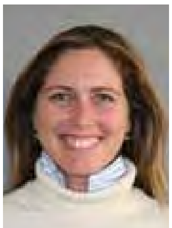

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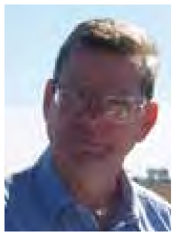

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Foreword

By **KEN FLOWER**

Welcome to this first edition of *The Australian Cotton Production Manual*.

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.

This manual seeks to achieve for Farming Systems in cotton production what the *Cotton Pest Management Guide* has achieved for Integrated Pest Management, that is, to provide all relevant information in one package as a first reference. The manual helps growers make well informed decisions through providing the latest research information and 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:

- A relatively young industry starting in early 1960s;
- A high and sustained investment in research;
- Industry wide input to research direction;
- An open, sharing culture leading to fast adoption of best practices as they evolve;
- High level of cotton specific training of personnel; and,
- Australia's open market maintaining our competitiveness.

The Australian cotton industry has undergone major challenges over the past decade bought about by the reduction in availability of water due to drought and government restriction and water buy back. With cotton area peaking at 511,000 hectares planted in 2000 through to a low of 68,000 in 2007, the whole industry from grower to research, development and extension (RD&E) has had to do more with less. 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.

This publication is one of the first in a series of key products to be delivered by the newly created cotton industry "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 lowest possible cost to the people on the ground. I do look forward to this collaboration continuing for future publications.

This will be a regular part of cotton production resources delivered by the industry from now on and I would urge all users to give feedback to any of the researchers, or the Development and Delivery Team members on any aspects you would like added to or improved in future editions.

Thanks again to the researchers and the Development and Delivery Team for this publication, which is now available for an anticipated influx of new and returning growers to the industry in 2010.

Ken Flower

General Manager Research Implementation and *my*BMP

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Cotton Research & Development Corp (CRDC)
Tel. 02 6792 4088
www.crdc.com.au

Cotton Catchment Communities CRC (CCCCRC)
Tel. 02 6792 2446
www.cottoncrc.org.au

Crop Consultants Australia (CCA)
Tel. 0429 925 459
www.cropconsultants.com.au

CSIRO (ACRI Narrabri)
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www.csiro.au

NSW Department of Industry & Investment (I&I)
ACRI Narrabri
02 6799 1500
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Cotton Seed Distributors (CSD)
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Contents

Introduction

By **MIKE BANGE**

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 this 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 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.

CONSIDERATIONS WHEN GROWING COTTON

- Suitable climatic summer cropping conditions
- Inputs in terms of costs – per acre ($.. dryland/$.. irrigated) and water availability (if irrigated), machinery start up costs.
- Cash flow budget is essential
- Services of a reliable and experienced consultant/ agronomist – (see your regional cotton officer).
- Availability of suitable machinery, either purchased, contracted or shared.
- When necessary contact an industry organisation (Cotton Research and Development Corporation/Cotton Australia/ Cotton Catchment Communities CRC/Crop Consultants Australia/ Department of Industry and Investment NSW/Qld Department of Employment, Economic Development and Innovation or Cotton Seed Distributors

Cotton flower.

These cottons have very good fibre properties demanding a significant price premium from spinners for manufacture of fine garments. They have 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 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 the Emerald and Burdekin Region of Queensland.

Constituting about 1500 growers in peak times during early 2000, the industry grew rapidly to become the nation's fourth largest rural export earner behind wool, meat and wheat, netting the country about $1.5billion annually in export sales and reaching 2.5 billion bales in 2004 when growing conditions were most ideal.

While in recent years drought and reductions in irrigation water allocation has seen the annual crop area markedly reduced, the industry has remained resilient and continues to improve and adapt to these changes through research and innovation. Fortunately the majority of crop management factors which increase/optimise yield will also increase/optimise fibre quality. 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 management practices. '*my*BMP' **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 *my*BMP website – www.mybmp.com.au for more details and to register.

Cotton Catchment Communities Co-operative Research Centre www.cottoncrc.org.au

Cotton Research and Development Corporation www.crdc.com.au

Cotton Australia www.cottonaustralia.com.au

Department of Industry and Investment NSW www.industry.nsw.gov.au

Qld Department of Employment, Economic Development and Innovation www.deedi.qld.gov.au

CSIRO www.csiro.au

Alternatively 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 or 02 6799 1534.

CHAPTER 1

*my*BMP

By **JIM WARK**

*my*BMP is a web-based management system that provides growers access to the Australian cotton 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, and provides growers with the tools required to improve production performance, better manage business risk, maximise potential market advantages and demonstrate responsible and sustainable natural resource management to the community.

*my*BMP 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

- *my*BMP can be accessed via www.mybmp.com.au – once on the home page, select the "Register Here" text and follow the prompts through the registration process
- **Support** – If at any time you have questions about *my*BMP, you can either email the *my*BMP Service Manager via admin@mybmp.com.au or call **1800 COTTON** for one on one support

What's new

- **A new system of classification – Level 1** is the entry level that covers off legal requirements and **Level 2** contains what is considered industry best practice. Together these two levels comprise the content required to complete *my*BMP certification. **Level 3** and **Level 4** are aspirational levels that cover those practices that will be considered best practice in the next 5 and 10 years respectively
- **Simplicity** – being web based, *my*BMP has done away with clunky manuals and paper based assessments. All information is lodged electronically and stored confidentially. *my*BMP allows the user to upload documents relevant to their *my*BMP practices in one easy to manage on-line filing cabinet.
- **No doubling up** – *my*BMP has the ability to cross-reference *my*BMP practices against the old BMP program, automatically populating completed practices from one system to the other. No time spent by the grower transferring data from the old system to the new

The new *my*BMP provides the tools required to improve production performance, better manage business risk, maximise potential market advantages and demonstrate responsible and sustainable natural resource management to the community.

Why use *my*BMP

- ***my*System** – tailored by you for you – *my*BMP allows you to work through the program modules in the order and to the levels that suit your business priorities. *my*BMP has been designed to accommodate all users – from the seasoned BMP user to growers who have never grown cotton or used BMP before
- ***my*Resources –** every practice is linked to its own reference source, with a pop up box that provides definitions, explanations, templates, calculators and links to further information. No more need for Google searches because *my*BMP provides access to all the latest information and research results in one easy to access place
- ***my*Insurance –** *my*BMP Level 1 practices provide guidelines and practical advice on how to comply with legal requirements ranging from the storage and use of chemicals to Human Resource requirements, helping you to better manage the risks associated with your business.
- ***my*Certification –** those growers who choose to seek certification will find the new and streamlined auditing process easier to manage
- ***my*Farm –** with the introduction of a web-based Grains BMP in Queensland, cotton's *my*BMP has the ability to cross reference your BMP practices against one another, automatically populating those practices that you have completed from one system to the other.

CHAPTER 2

Dryland cotton potential and risk

By **MIKE BANGE**

This article presents information to demonstrate and quantify the yield potential, reliability and risks for dryland cotton. Extensive research has utilised 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 have used long-term climatic records (1957 onwards from the Bureau of Meteorology) and the OZCOT crop simulation model developed by Brian Hearn 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 provide slowly available soil water to the planted rows to allow continued growth during dry periods. In practice, however, the benefits lie primarily in: (a) a reduced risk of negative effects of water stress on fibre quality, (b) reduced yield variability, and (c) better economic returns due to production costs being reduced more than the yield relative to solid planted cotton.

KEY POINTS

- A full soil profile is desirable.
- Sowing should occur in the Oct 1 to Nov 15 window.
- Skip row configurations are generally more reliable.
- Mean yield across most regions was slightly less for double skip compared with single skip however; there were more chances of attaining better yields for double skip on soils with lower plant available water holding capacity.
- On average fibre length is improved with both skip configurations.
- Seasonal outlooks such as the El Niño - Southern Oscillation (ENSO) phenomenon should also be considered as it can lead to differences in potential yield and risks with different configurations.

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).

Predicting dryland cotton yield potential

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

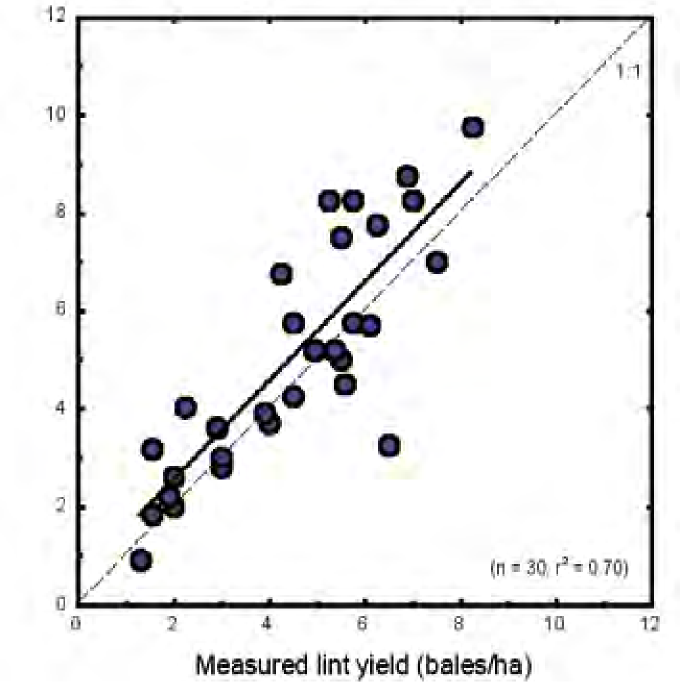
- Cracking clay soils storing 200mm or 250mm of available soil moisture in 1.5 m profile. A full profile at sowing.
- Siokra (Bollgard II) variety.
- Crops sown on the 30th October.
- Row spacing set at 1 m.
- Established population of 7 plants per metre of row.
- Nitrogen non-limiting
- Climate data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

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

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)



than N. The model also does not simulate the effects of climate and 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 the 15th of September. A sowing opportunity was defined in terms of adequate soil moisture and temperature: 25 mm (1″) of water in top 100 mm (4″) soil. 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.

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 plant configurations. They generally show that when yields of solid configurations are high,

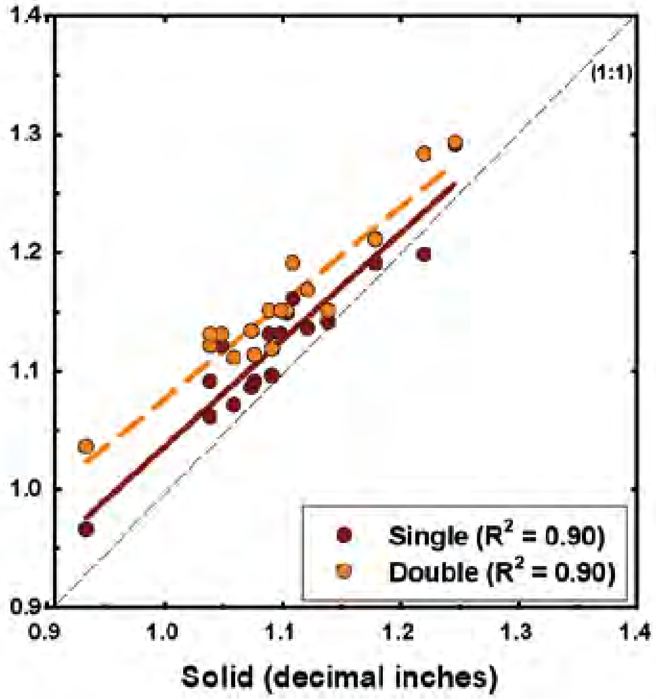
TABLE 2.
Probability of failing to sow based on the sowing rule (defined above) for different periods starting 15th September.

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

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

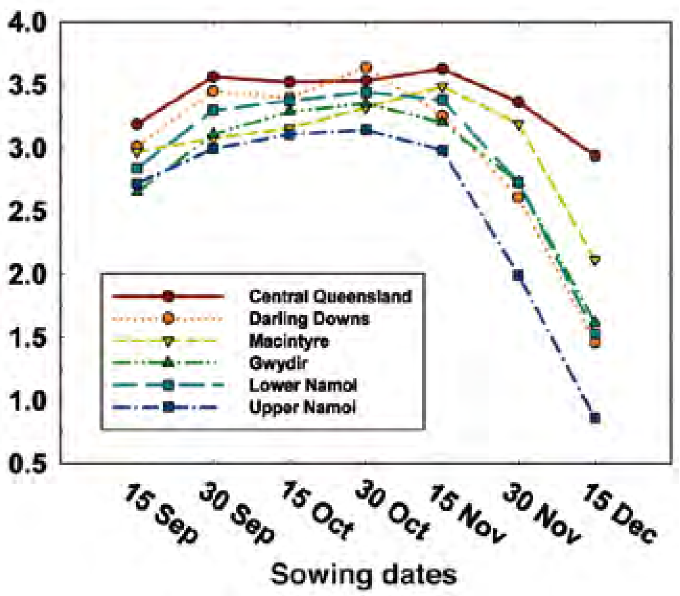
FIGURE 2.
Fibre length of skip row configurations compared with solid row configuration in dryland cotton systems. As points approach the 1:1 line fibre length of the skip configurations equals that of the solid configuration (M. Bange, CSIRO). Note that this data is not simulated data.



skip row configurations have a penalty; however when yields of solid configurations are low the difference in yield between skip rows and solid configurations are small.

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.

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.



Generally across all regions yields were improved with single skip and overall yield variability was reduced. Yield was also lower for solid and variability was higher. Mean yield across most regions was slightly less for double skip compared with single skip however; there were more chances (higher 80% and lower 20 probability of exceedence) of attaining better yield with the soil with lower plant available water (200mm). Conversely across regions single skip had better chances of achieving higher yields more often on soils with 250mm of plant available soil water. 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 that point.

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

Time of sowing

In all regions mean yields of crops grown in single skip configuration were less when crops were sown before the 30th September (Figure 3). The latest sowing date where there was no substantial penalty to average yield was the 15th November for all regions with the exception of the Darling Downs, where yield reduced after the 30th October. The optimum sowing time for most regions based on mean yields was from 15th October to the 15th November. Later sowings in 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 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.

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

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.

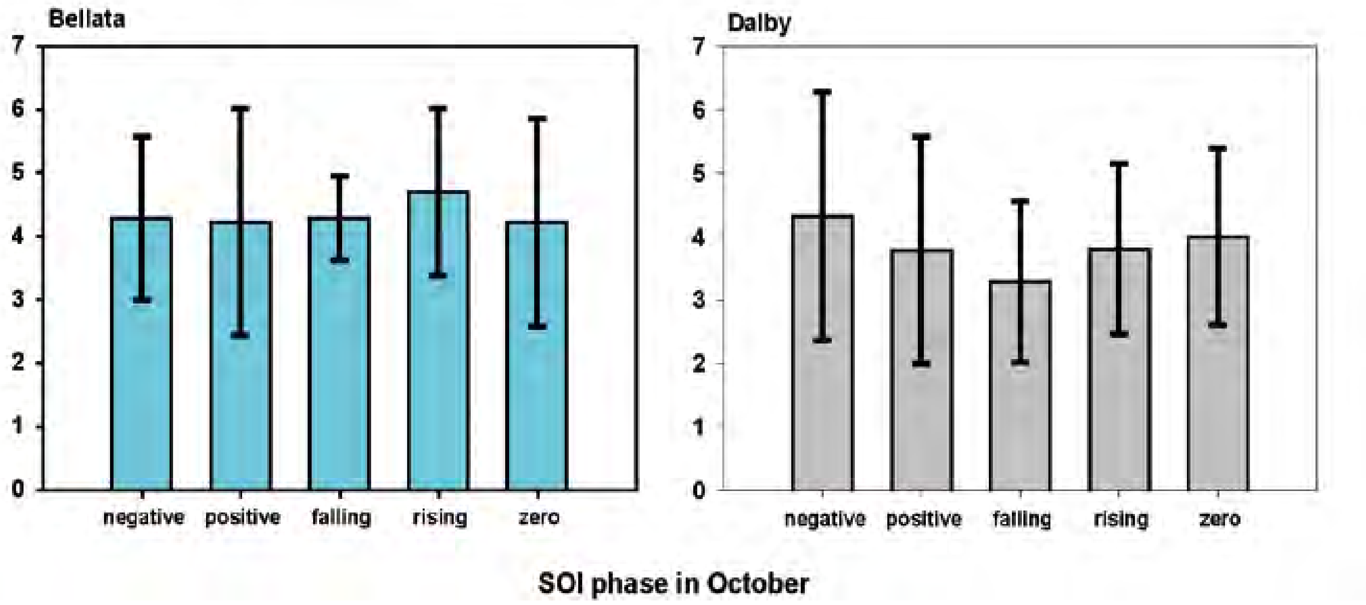
Region	200mm Plant Available Soil Water			250mm Plant Available Soil Water		
	Mean	80%	20%	Mean	80%	20%
Gunnedah	3.2	2.5	4.0	4.0	2.9	4.9
Wee Waa	3.4	2.3	4.6	4.2	2.7	5.2
Bellata	3.6	2.6	4.6	4.3	3.1	5.4
Moree	3.3	2.4	4.3	3.4	2.5	4.2
Croppa Ck	3.3	2.3	4.5	4.3	3.1	5.9
Goondiwindi	3.4	2.3	4.3	3.6	2.8	4.3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

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
Central Qld.								
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
Darling Downs								
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
Macintyre								
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
Gwydir								
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
Lower Namoi								
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
Upper Namoi								
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 above for a 250mm plant available soil water profile) for 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.



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.

Below we illustrate how using OZCOT when used 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 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 consistent 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.

probability.

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.

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Chapter 3

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Crop economics

By **FIONA SCOTT[1] & JANINE POWELL[1]**

[1](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 payment structure of a contract that will suit your needs 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.

These sensitivity charts reflect the resulting changes to crop gross margin from a 20% change in both yield and lint price from typical levels. The charts indicate that the profitability of a cotton crop is highly sensitive to both changes in yield and the cotton lint price.

Whilst the charts only reflect a 20% change above and below typical yields & prices, it is important to understand that the range of potential yields and prices is much wider than this. This emphasises the importance of the budgeting process, in particular using achievable yield and price figures.

FIGURE 1.

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

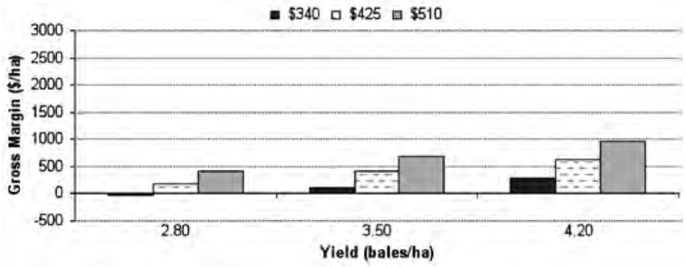
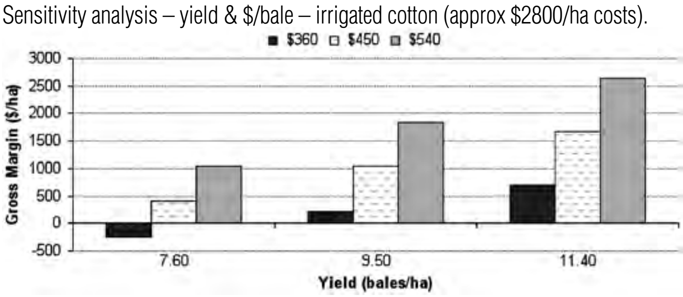


FIGURE 2.

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

KEY POINTS

- Budgeting is essential.
- Don't 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.

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 farms 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)
- No labour costs (except for chipping).
- 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 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

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

IRRIGATED COTTON (Roundup Ready® OR Roundup Ready Flex® Bollgard II®)	
Income	
9.5 bales/ha @ $450/bale	$4,061.25
2.95 t/ha seed @ $240/tonne	$671.46
TOTAL INCOME (A)	**$4,733**
Variable Costs	
Cultivation	$11.77
Seed and sowing	$96.95
Fertilisers	$626.25
Herbicides	$128.37
Insecticides	$53.14
Defoliants	$86.93
Boom applications	$12.80
Aerial applications	$68.00
Irrigation (C) 7 ML	$231.00
Insurance	$55.00
Consultant	$60.00
Casual Labour (eg chipping)	$60.00
Stalk pull & mulch	$75.00
Licence fees	$390.00
Contract harvesting	$285.00
Module lifting	$28.50
Cartage	$83.13
Ginning	$522.50
Levies	$42.75
TOTAL VARIABLE COSTS for Bt	**$2,917.08**
Pigeon Pea refuge Crop	
Cultivation	$106.82
Seed and sowing	$75.68
Herbicides	$152.74
Boom applications	$6.40
Irrigation	$112.20
Slashing	$12.00
REFUGE CROP VARIABLE COSTS	**$465.84**
Proportional Variable costs (Bt)	$2,771
Proportional Variable costs (refugia @ 5%)	$23
TOTAL VARIABLE COSTS (B)	**$2,795**
GROSS MARGIN/HA (A-B)	**$1,938**
GROSS MARGIN/ML (A/C)	**$277**

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Machinery requirements

By **PETER HUGHES,** QDPI

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

KEY POINTS

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

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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.

CHAPTER 5

Energy and associated greenhouse gas emissions

By **CRAIG BAILLIE**

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, energy inputs can represent 40 – 50% of the cotton farm input 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. 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 (Chen and Baillie, 2007) 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_2 equivalent/ha greenhouse gas emissions. Dry land cotton production in comparison is expected to be at the lower end of this range.

KEY POINTS

- 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.

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).

Assessing the farms total energy use and associated greenhouse gas emissions

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 greenhouse gas emissions (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) has been developed by the National Centre for Engineering in Agriculture (Baillie et al, 2009) 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

Detailed monitoring may include performance of pumping systems and stationary motors.

Minimum tillage can reduce energy consumption by at least 10%.

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 to derive the energy insensitivities of the site. 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 ±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 ±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 Table1.

TABLE 1.
CO_2 Emission factors.

Energy sources	Emission Factor kg CO_2 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) 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).

Previous work (Chen and Baillie, 2007) including irrigated cotton production has shown that GHGs have ranged from 275 to 1404 kg CO2 equivalent/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 tertiliser which can be determined by the Cotton Greenhouse Gas Calculator.

Energy saving practices

Previous work has shown that on farm energy use between different farming enterprises can vary significantly. Generally lower energy use is a function of the number and intensity of farming operations. 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 up to 50% of the total direct energy use. Compared with cotton, the energy use of other rotational crops is generally lower; however this is a result of the number of farming operations and energy requirements associated with cotton production such as picking and greater irrigation requirements.

Spraying significantly reduces fuel use compared to tillage options.

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Cotton Greenhouse Gas Calculator developed by Dr Peter Grace, QUT (http://www.isr.qut.edu.au/tools/index.jsp)

Precision Agriculture in cotton farming systems

By **ANDREW SMART**

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; and,
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 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.

KEY POINT

- Precision Agriculture can assist with better crop production decisions based on in-field variability.

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 change and to attempt to comprehensively understand what site-specific combination of factors are present.

While there are many ‘tools’ available to measure variability in cotton, 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).
- 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, 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

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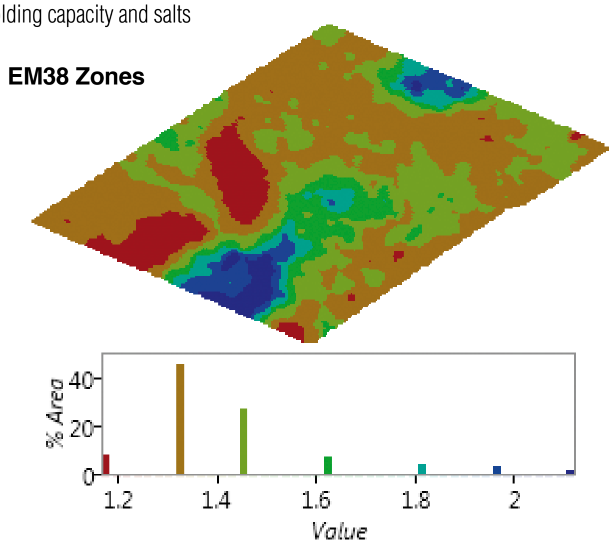
IMAGE 1.
EM38V survey captured with full moisture profile.
Red = low conductivity and blue = high conductivity. Low EM zones represent lower clay, water holding capacity and salts. High EM zones represent higher clay, water holding capacity and salts



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 (i.e. some fields may have fewer areas with high subsoil constraints, therefore chickpea yields would be reduced).
- To optimize 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 PAW.
- 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.

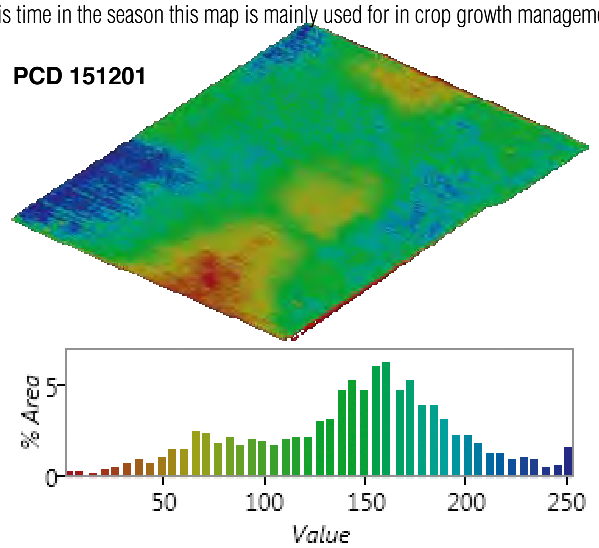
Plant Cell Density (PCD) and Normalised Difference Vegetation Index (NDVI) are indices which use the red and near infra-red (NIR) bands and have been used extensively in cotton farming systems for;

- 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.

IMAGE 2.
Airborne imagery captured on 15-12-01
Red=low biomass and blue = high biomass.
At this time in the season this map is mainly used for in crop growth management.



Topography is however a primary determinant of the 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.

IMAGE 3.
Slope% map created from an RTK tractor steering system.

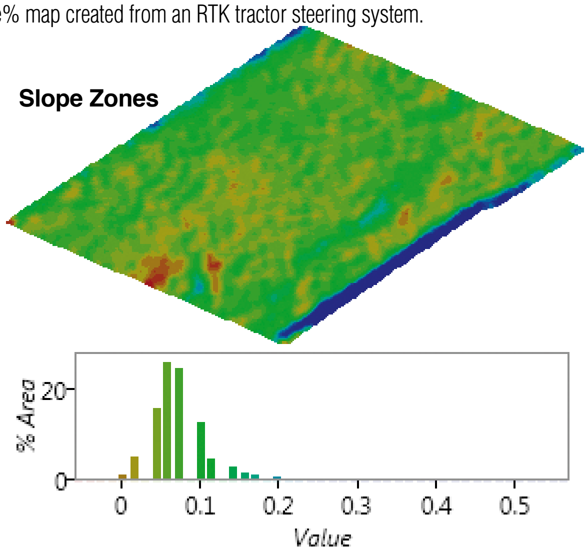
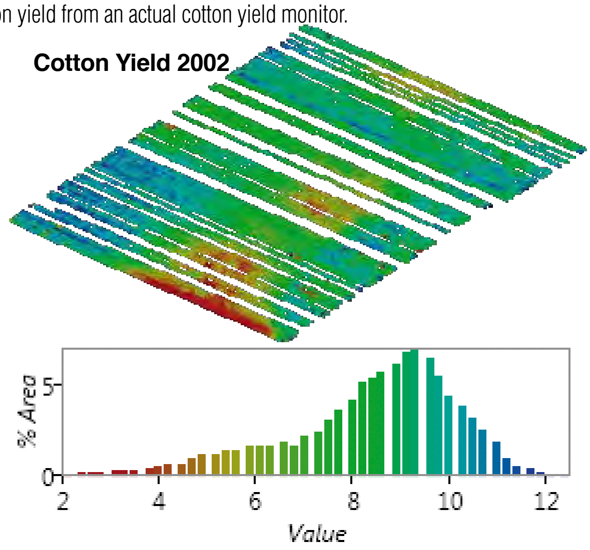


IMAGE 4.
Cotton yield from an actual cotton yield monitor.



- 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 analysis 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.

An example on analysis of the interaction of layers is shown in Figure 1. In this case the Cotton Yield in 2002 (y-axis – right) is overlaid on the EM zones (x-axis). In this situation the highest yielding zones (a) are also our higher area zones (y-axis- left) (b) and low EM zones. This indicates water was managed well in this irrigated field. The addition of a profit/ha line (c) (y-axis-far right) allows analysis of 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 (d) but only encompass a total area of approximately 3ha.

Summary

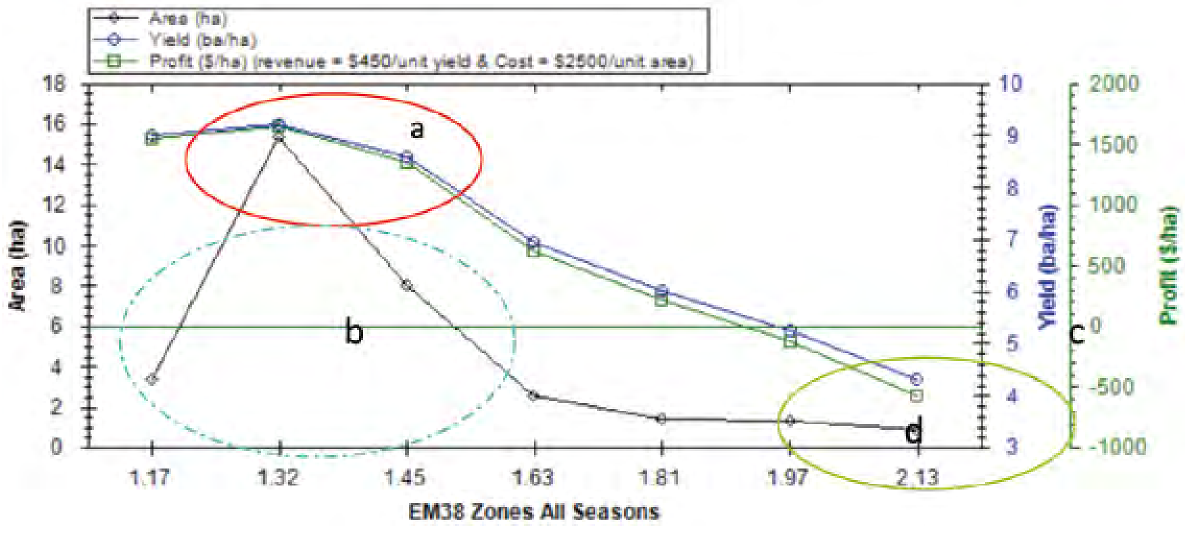
Growers all across the cotton producing regions of Australia are starting to realize the benefits of PA. For some the benefits flow quickly, while for many a lead time of data collection, analysis, and knowledge enhancement is required before realistic management plans can be implemented to manage spatial variability.

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.

FURTHER INFORMATION

Andrew Smart, email andrew@pct-ag.com

FIGURE 1.
EM38 zones all seaspns vs cotton yield 2002.



CHAPTER 7

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Managing for fibre quality

By **MICHAEL BANGE**

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/optimise yield will also increase/optimise 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 elongation1 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 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 tertiliser 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 the following Table.

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.cottoncrc.org.au/content/Industry/Publications/Fibre_Quality/FIBREpak.aspx

[1]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.

KEY POINTS

- Australia needs to maintain its reputation as suppliers 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 *my*BMP.

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 12.7 mm.	< 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 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. Strategic planning for irrigation availability. 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, fertliser and growth regulators. Adopt IPM to protect fruit, and leaves.	Timely harvest to avoid bad weather. Use appropriate nitrogen tertiliser rates to match crop and tertiliser cut out. 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.		Tertiliser, 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.

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Field preparation

By **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 and vigorous root growth - provide favourable conditions. Soil types with dense, sodic subsoil's have poor profile permeability and drainage.

Structural damage, due to excessive traffic or tillage at incorrect moisture contents, may create large platey 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.

KEY POINTS

- Soil surveys are useful in the planning of a new cotton field.
- A paddock with a uniform soil type is easier to manage.
- Fix problems associated with land forming before planting cotton.

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, large values of PAWC delay the onset of moisture stress in crops.

Total PAWC is poor in shallow soil over bedrock, in sandy soil, and in soil with dense sodic subsoil. The ability of crop roots to access the available soil moisture is reduced by structural damage.

Compaction may also reduce the ability of a soil to allow water entry. Slope, surface drainage, waterlogging and flooding. 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 lazer 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.

Slope

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 under cotton, 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.

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.

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

Land forming and lasering

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

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

Row configurations

By **DAVE KELLY**

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.

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.

The advantages and disadvantages of each configuration

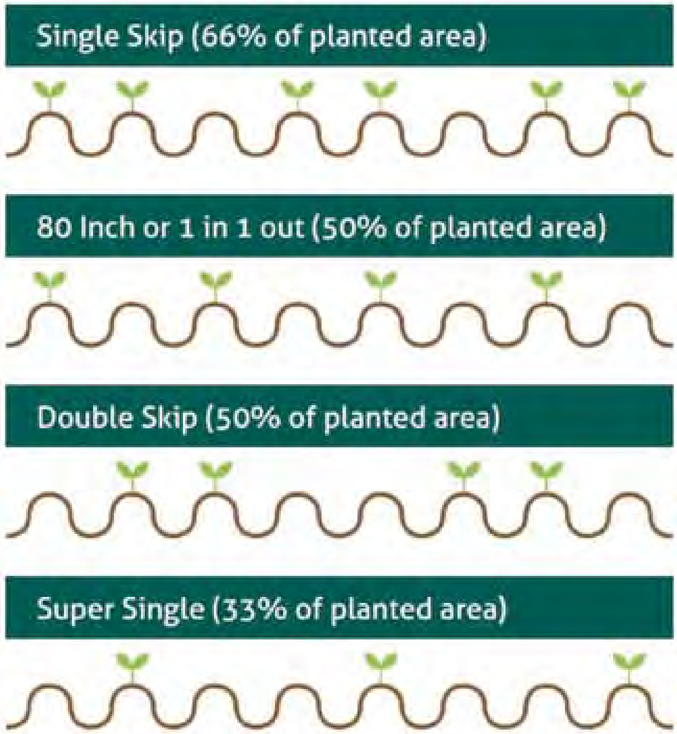
Extensive research has shown that while skip row cotton does limit yield potential (Figure 2), the combination of reduced fibre length discounts and variable cost savings in growing skip row cotton often lead to a better risk/return proposition.

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

KEY POINTS

- 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.

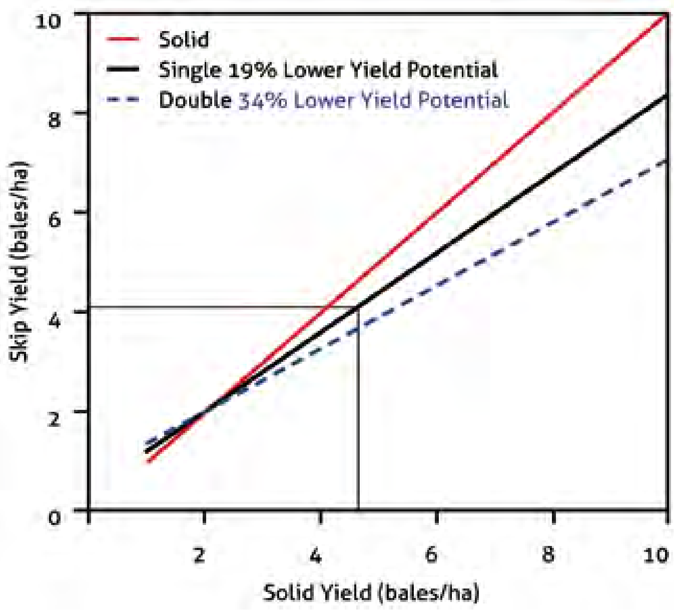
FIGURE 1.
Row configuration guide (Source: CSD Getting the most out of skip row irrigated cotton)



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 2 metres (80 inch) cotton can reduce lodging; allow better spray penetration and defoliation processes when compared to double skip.

Other advantages perceived by some double skip growers compared to 2m 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 row is in the middle of a 2m bed.
- Watering up – 2m 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 chapter on risk in dryland systems).

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, defoliants 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 affects 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

Crop establishment

By **JAMES QUINN & DAVE KELLY,**
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James Quinn.

Dave 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.

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

KEY POINTS

- 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.
- Further information is available on the CSD website or by contacting the CSD team.

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).

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 plant/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°C- 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.

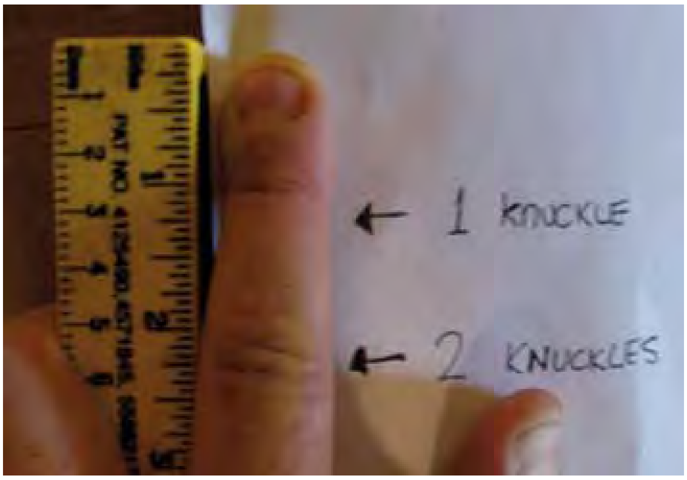
- Check that monitors are calibrated and working correctly.
- Chains and cogs need to be properly adjusted and lubricated.
- Spray lines and filters should be cleaned to stop blockages when planting herbicides or when in-furrow sprays are to be used.
- During the operation, regularly check seed depth 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 ½ cm 1 to 1 ½ knuckles

Important considerations

- 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 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.

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

Establishment Method	Ideal depth
Planting Dry and Watering Up	2½ cm 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 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

Planting into moisture.

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:

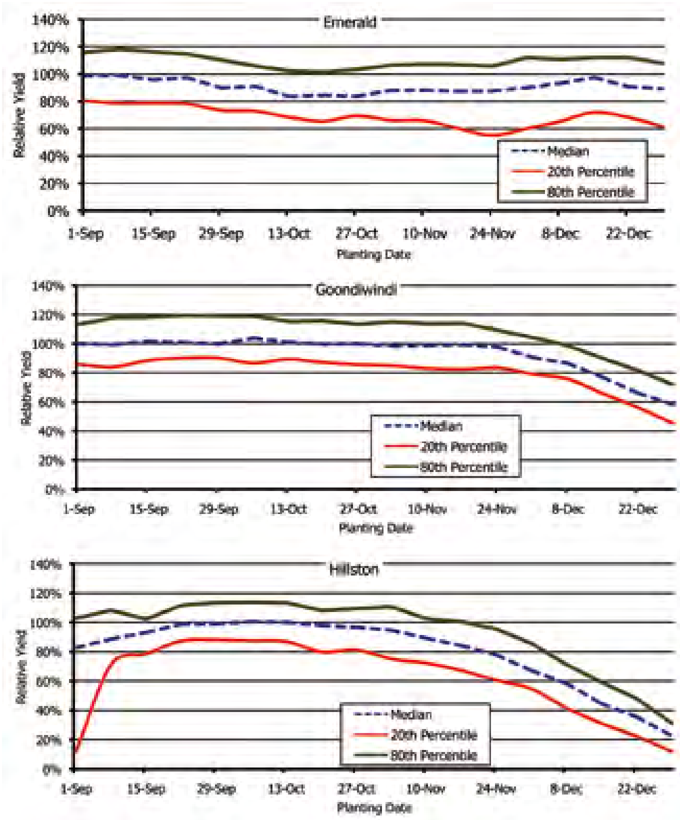
- It will increase the likelihood of warm temperatures at planting, resulting in increased seedling survival and vigor.
- A crop established under warm conditions has the potential to produce bigger plants, hence greater leaf and stem area to sustain boll development later in the season.
- Later planting 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..

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.

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.

- 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 hilled 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?"

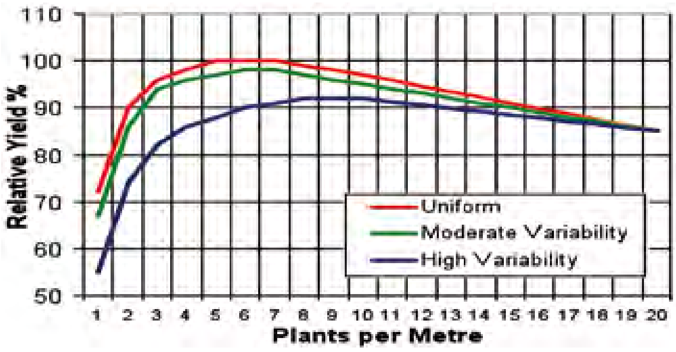
The decision needs to be made carefully, based on good field information on the current population, its health, the cause of the stand loss the implications of replanting and the implications of managing a low plant stand. Some factors to consider:

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 50 cm 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 that 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 geminates 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

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

Sponsored by – CGS

Crop growth stages

By **JAMES QUINN & DAVE KELLY,**
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Dave 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: Maximum temp = 30°C, Minimum Temp = 20°C

$$\frac{(30-12) + (20-12)}{2} = 13 \text{ Day Degrees}$$

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

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

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

KEY POINTS

- 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.

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

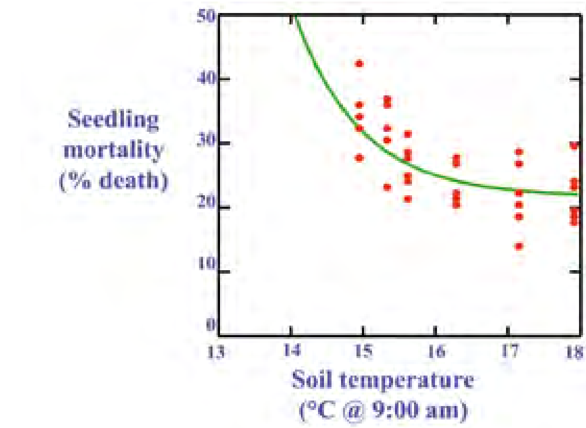
In very high temperatures as well as crop development being slowed so is crop growth. Very high temperature increase the use of plant uses resources and energy to transpire and respire in an effort to keep cool. In addition reduced leaf biomass and fruit shedding can be a result of high day and night 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 quicker this will happen. Seedling establishment is best if minimum soil temperatures in the seed zone are at least

FIGURE 1.
Impact of soil temperature on Seedling Mortality. Temperature is the average minimum soil temp. for the 7 days after sowing.



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

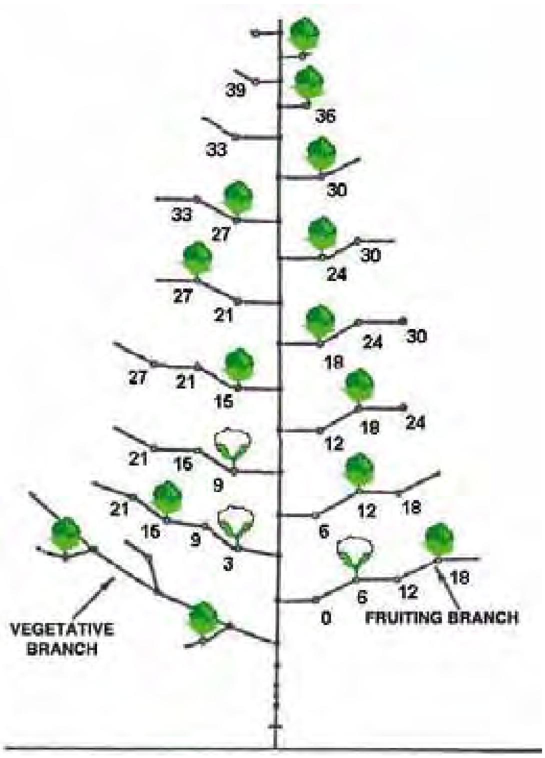
The cotton plant has an indeterminate growth habit, which means it puts its fruit on over a period of time not all at once. The rate of development can be mapped through the life of the crop and it follows a specific pattern. This growth is driven mainly by temperature and therefore we use the day degrees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

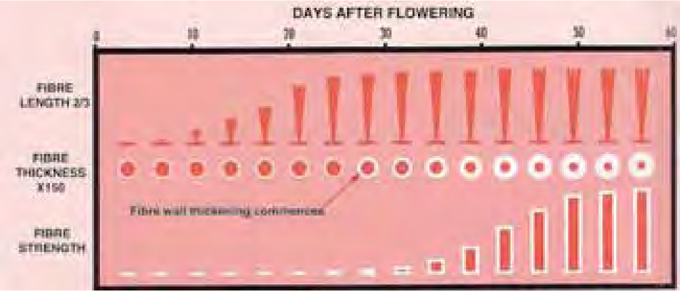
Boll filling

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 in 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

'Cut out' is the term used to herald the last effective flower, or when all the fruit that you will harvest is on the plant. It signals the end of reproductive growth, no more new fruiting sites will be established and the plant concentrates on maturing the remaining fruit. It normally occurs when the plant reaches four Nodes Above White Flower. At this point the crop has set all of its fruit and goes about the process of maturing the remaining bolls. 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.

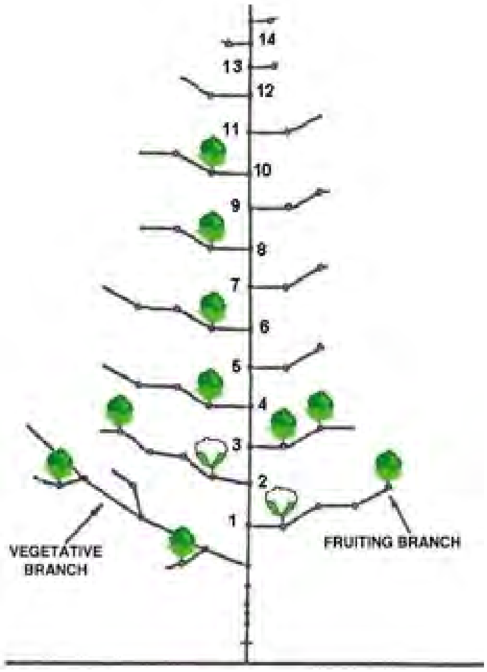
When NACB doesn't work

In situations such as heavily tipped conventional crops, 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.

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**.



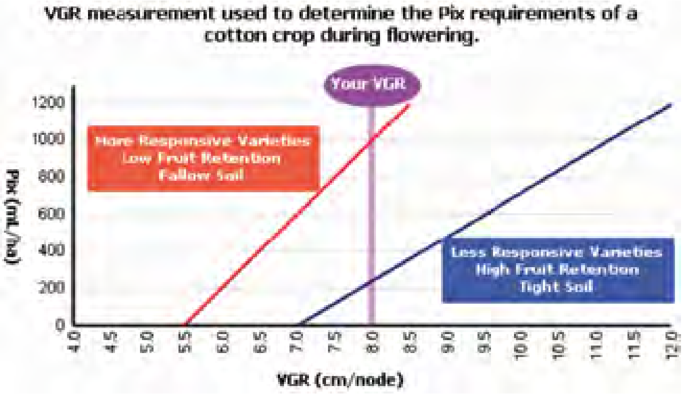
Measuring Vegetative Growth Rate (VGR)

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.

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

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

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

FURTHER INFORMATION

Crop Development Tool – www.cottassist.cottoncrc.org.au

CSD – www.csd.net.au

CHAPTER 7e

Sponsored by – CGS

Varietal selections

By **ROB EVELEIGH**

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).

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 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

KEY POINTS

- The full range of cotton varieties available are outlined at www.csd.net.au.
- 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 verticilium 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

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 1980's. 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.scd.net.au

Biotechnology traits

By **STEVEN AINSWORTH**

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.

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 derived from Baccilus 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 utilizes the herbicide glufosinate which has particular strengths including the ability to control hard-to-kill weeds like peach-vine which are not well controlled by glyphosate. Liberty herbicide also provides useful control of glyphosate tolerant cotton volunteers.

Stewardship

All biotechnology traits commercialized in Australia are supported by an appropriate stewardship program which forms part of the annual Technology User Agreement (TUA) between technology owners and growers. Stewardship of these current traits is important to ensure they continue to provide value to growers, pro-actively manage resistance risks and more importantly provide a basis for the introduction of new novel traits to solve other production and environmental challenges.

Specific information on these traits can be found at the following websites:

www.monsanto.com.au/products/cotton/

www.bayercropscience.com.au/

®Bollgard II and Roundup Ready Flex are registered trademarks of Monsanto Technologies LLC, used under license by Monsanto Australia Ltd.

®Liberty Link is a registered trademark of Bayer CropScience.

HOW ABOUT A SECOND OPINION?

Recent surveys have shown that Australian cotton growers on average apply 50kg of Nitrogen per hectare in excess of optimal crop requirements.

NutriLOGIC allows you to estimate fertiliser needs for irrigated cotton based on results from nutrition researchconducted in Australia.

NutriLOGIC is availiable at www.cottassist.cottoncrc.org.au

Contact Sandra Deutscher for more information.

☎ 02 6799 1500 sandra.deutscher@csiro.au

Best Practice

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.

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.

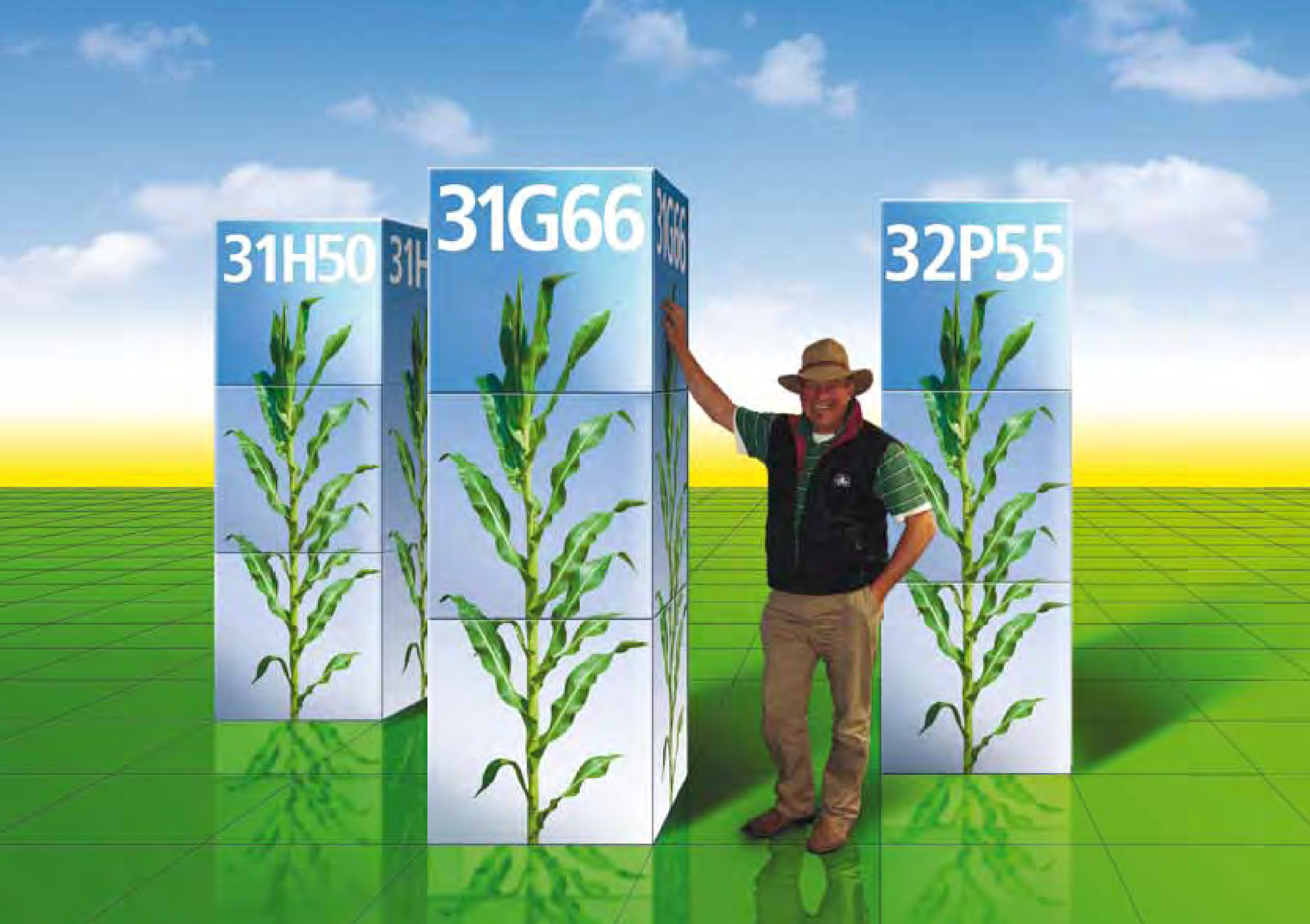
KEY POINTS

- 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.

FURTHER INFORMATION

The Cotton Rotation Finder - http://www.cottoncrc.org.au/content/Industry/Tools/Agronomy_Tools/Cotton_Rotation_Finder.aspx

Plant the right corn hybrid in the right paddock for maximum yields.



Start every season with a plan to put the right corn hybrid in the right paddock.
Pioneer brings more potential to the table so you get more potential from your crop. Every bag of Pioneer hybrid corn seed contains diverse genetics combined with advanced protection traits. And all Pioneer hybrids are rigorously tested to make a difference on your farm, paddock by paddock.

So whether you are growing corn for processing grain, feed grain or silage, better choices lead to better yields. Because with Pioneer, it's Technology That Yields®.

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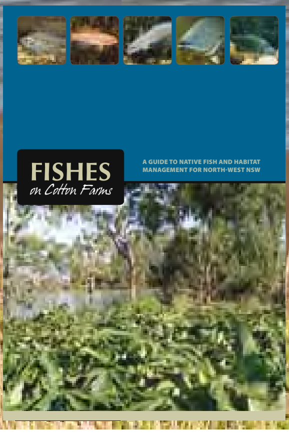


All publications are availiable at www.cottoncrc.org.au

Contact Peter Verwey for more information.

☎ 02 6799 2476 peter.verwey@cottoncrc.org.au

Best Practice

Cotton nutrition and soil health

By **DUNCAN WEIR & IAN ROCHESTER**


Duncan Weir.


Ian Rochester.

Maintaining 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, irrigation water etc. The development of a considered, balanced nutrient management plan for the crop will optimise yields, improve nutrient use efficiencies, reduce 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. 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.

Additional information is available in NUTRIpak, available on the Cotton CRC website.

In maintaining good soil nutrition a grower needs to:

- Determine soil nutrient status using pre-season soil testing
- Calculate expected crop nutrient requirement taking into consideration expected yield, cropping

KEY POINTS

- To maintain good soil nutrition a grower needs to:
  – Determine soil nutrient status (soil sampling)
  – Calculate expected crop nutrient requirements
  – Implement a fertiliser plan – fertiliser choice, rate, application, frequency, timing
  – Monitor crop nutrient status – petiole and leaf analysis
  – Develop a crop nutrition and soil health management plan
- The 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 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	68	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	13
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	212
15	200	35	55	16	8	22	92	34	157	230	22
16	215	37	59	17	9	23	99	36	166	244	24
17	230	40	63	18	9	25	106	38	176	257	25
18	245	42	67	19	10	26	113	40	185	270	27
19	260	44	70	20	10	28	120	42	195	283	28

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


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

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)

- Develop a fertiliser use plan that ensures expected crop demands for nutrients are met, while optimising the use-efficiency of each nutrient and minimising 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. Soil analysis should be a routine part of your management as it provides an indication of the fertility level in your soil at that point in time. Growers can either sample the soils themselves using commercial soil sampling kits or send them to an accredited laboratory for analysis or, they can engage a service provider 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 manual for more details on EM surveys.

When choosing a laboratory to conduct your testing, insure 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 that are being conducted are going to provide the information that is required and in a form that can used.

For more information on sampling refer to 'The soil sampling and analysis guidelines' – CRC website.

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 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 is well supported and can be accessed through CottASSIST at : www.cottassist.cottoncrc.org.au/

Develop a fertiliser plan

Having analysed soil and assessed fertiliser requirements for the coming crop, the grower needs to decide on rates of each nutrient to be applied, in what form (type of fertiliser) to be used, when to apply them and the method of application.

This requires working through a number of considerations, all of which depend on each other:

- **Which fertiliser to apply:** there are different types or forms of tertiliser that 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 specialized equipment by trained staff, and foliar tertilisers need to be applied evenly and in a timely manner.
- **When to apply:** 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) tertiliser 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 becomes critical, irrigation and rain can impact on the capability to apply tertilisers in a timely manner increasing the risk of crops being stressed at critical times.
- **What rate to apply:** The tertiliser rate will depend on the type of tertiliser being used and when it is being applied. The composition of the tertiliser (percentage of each nutrient in the tertiliser) will dictate just how much of the product needs to be applied to meet the crop requirement. If all the tertiliser is being applied up front, an adjustment must be made to take into

consideration losses and inefficiencies. On the other hand, if a starter tertiliser is being used at planting with later in-crop applications, the rate of tertiliser 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. Nitrogen contained in fertilisers can be lost to the atmosphere through ammonia volatilisation and should be applied below the surface or 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 are quite limited and may not be able to sustain the need for those nutrients. Applying fertilisers too close to the plant line may cause seedling damage due to the salt effect.

Plans must be flexible with the capacity to be modified through the season if for example leaf or petiole analyses suggest additional fertiliser is required or weather conditions change.

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). Remember that results can only be as good as the sample provided, so careful consideration to sampling procedures is important.

More information about Leaf and Petiole Sampling and analysis can be found in NUTRIpak.

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 impacts which can develop through poor farming practices so it is critically important to develop long term production programs and systems which seek to prevent or remedy these problems. 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 of this chapter.

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 reduced costs and improved productivity.

Legumes

Incorporating a legume into your crop rotations can significantly improve soil nitrogen fertility through its capacity to fix atmospheric nitrogen into a plant available form. They also can have beneficial effects on soil structure and plant disease management.

Information about the amount N fixed and residual soil N of various legume crops can be found in NUTRIpak.

Recent work has shown significant financial and agronomic benefits of including vetch into the rotation.

More detailed information can be found in the Agronomy and Nutrition publications on the Cotton CRC web site.

Nutrients

Nitrogen

Nitrogen is a major plant nutrient being an integral component of proteins, essential for crop growth and physiological development. It is also required for the synthesis of chlorophyll needed for photosynthesis. Nitrogen is a mobile nutrient that should be monitored 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.

Cotton sources most of its 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 - 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 - nitrates are washed through the soil profile out of the root zone
- Volatilisation - nitrogen in the form of ammonia is lost to the atmosphere. Particularly important when solid fertilisers are applied and are not incorporated properly and 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 and result in reduced yields, quality down grades, increased production costs as a result of increased use of growth regulators and defoliants, higher fertiliser costs and reduced N efficiencies.

For more detail of nutrient management and its impact on fibre quality refer to page 51 in FIBREpak.

Anhydrous ammonia (82% N) and Urea (46% N) are the two major nitrogen fertilisers used in the cotton industry. Both provide N in an available form. 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.

Legumes can play an important role in a cotton cropping system. They provide a valuable source of nitrogen as well as improving soil health. Incorporating a legume into your crop rotations can significantly improve soil nitrogen fertility through the 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.cottoncrc.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.cottoncrc.org.au/files/c82c2fe2-f2c9-4c94-af82-9ad600bec0ca/Healthy%20Soils-VETCH%20(Low%20Res).pdf

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

For more details on the role of N, its importance, the nitrogen cycle and how it is managed refer to NUTRIpak.

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 P 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 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 moves in and out of solution, acts to buffer the available P in solution); and,
- Non labile P (very insoluble P unavailable to plants).

Actively growing cotton plants take up available P from the soil solution. As this supply is depleted, labile P replenishes and maintains the available P. i.e. acts as a buffer. With continued cropping, the level of labile P declines and is less able to replenish and maintain available P. When P fertilisers are applied to soils, much of the P ends up as labile P. P is normally applied pre plant as a starter with N to enhance growth and increase efficiency.

Banding fertilisers which contain P is the preferred method of application as the P remains in solution for a longer period. MAP (N:P:K – 9:22:0) and DAP (N:P:K – 18:20:0) are the most commonly used P fertilisers. 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.

For more details on Phosphorus, its importance, the phosphorus cycle and how it is managed refer to NUTRIpak.

Potassium

Potassium (K) is a mobile nutrient within the plant involved in energy transfer, osmotic regulation, 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, as well as premature senescence.

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 detailed on K, its importance, the K cycle and how it is managed refer to NUTRIpak.

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 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 is best broadcast and worked into the soil. Zn can 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 amounts, deficiencies are very rare.

For more details on any of these minor nutrients, their importance, and how to manage them, refer to NUTRIpak.

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, balanced nutrient availability, low sodicity and adequate soil mycorhiza. 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's chemical and physical properties, is critical 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.

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 usually occurs as a result of ground water rising to within 2mtr of the soil surface. 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 in the Soils, Agronomy and Nutrition publications on the Cotton CRC web sites.

For further help with monitoring and managing salinity and sodicity, refer to the Soil Health module in myBMP.

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.

More detail on soil compaction can be found in SOILapk on the Cotton CRC web site.

Water logging

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 ie lateral move or pivots

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

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 to8.5) effecting the availability of many micronutrients. This should be considered when calculating fertiliser programs.

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. Low VAM can lead to poor performance in cotton crops in particular in long fallow dry land cotton systems.

FURTHER INFORMATION

NUTRIpak - http://www.cottoncrc.org.au/content/Industry/Publications/AgronomyNutrition/NutriPAK.aspx

NutriLOGIC - http://www.cottassist.cottoncrc.org.au/

Nutrient sampling guidelines for cotton - http://www.cottoncrc.org.au/files/0b13f3af-7ac6-4c68-910f-995a00f901b3/SamGL06.pdf

Nutrients removed in harvested seed-cotton - http://www.cottoncrc.org.au/files/4eab6e0b-514a-4eeb-94e8-995a00f90139/CGNutRem.pdf

SOILpak - http://www.dpi.nsw.gov.au/agriculture/resources/soils/guides/soilpak/cotton

***my*BMP – www.mybmp.com.au**

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.

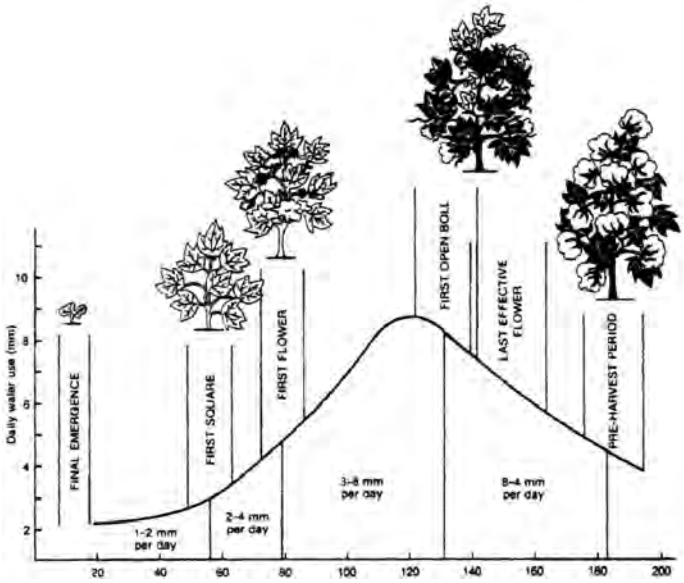
Dryland growers can use 'HowWet?', a Windows based program which uses farm rainfall records to estimate how much plant available water has been stored in the soil and the amount of organic nitrogen that has been converted to an available form during a fallow (non-crop period). 'HowWet?' tracks daily 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.

For further information about 'HowWet' go to: http://www.apsru.gov.au/apsru/Products/HowWet/how%20wet.htm

KEY POINTS

- Poor quality irrigation water can cause reductions in cotton growth and soil degradation.
- 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.
- The prime objective of the last irrigation is to ensure that boll maturity is completed without water stress
- For further support in all aspects of crop water use refer to the Water Management module in myBMP.

FIGURE 1.
The changing scale of water use by the cotton plant as it moves into each stage of growth



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.

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.

For more information on row spacing refer to the Row Configuration chapter in this publication.

Water in furrow

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 reductions in cotton growth and soil degradation. These consequences can be minimised or avoided by vigilant crop and soil management, but this does involve additional costs (see pg 257 of 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 can help growers make water shandying 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.

Water logging

Because clay soils drain slowly, many cotton crops are subjected to some degree of water logging (see the "Field Preparation" chapter in this publication). 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 water logging 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 water logging 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 there but they won't be as severe because the fruit is basically established on the plant.

Plants exposed to rainfall induced water logging 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 water logging on the crop, there are also significant impacts on nutrient availability and uptake. Water logging 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 water logging events not only contribute towards improved yield and water use efficiencies but can also benefit crop nutrient efficiencies. Water logging 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.

Optimized irrigation system designs allow delivery to the head ditch, run-times and tail water collection / return such that exposure to water logging and deep drainage are minimized.

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.

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.

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.

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 Mr. Steve 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.

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.

Research by Yeates has shown that low deficit scheduling or frequent watering eg 40mm 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.

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) to help keep track of how the crop is progressing

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 the last 25–30 days, on most clay soils. 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 5–7 mm/day, and may decline to around 3–4 mm/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. 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 (Refer to the Crop Growth Stages chapter in this publication).

“The prime objective of the last irrigation is to ensure that boll maturity is completed without water stress” (WATERpak pg93). 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.

FURTHER INFORMATION

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

‘Getting the most out of skip row irrigated cotton’ – www.csd.net.au

Water Quality Calculator – http://cottassist.cottoncrc.org.au

CHAPTER 11

Weed management

By **JAMES HILL**

Developing an IWM strategy for your farming system

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

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. 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.

KEY POINTS

- 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 Australia 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 *my*BMP.

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 selecting 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 – have resistance to glyphosate. Weeds with resistance to multiple herbicides is 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.

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.

Identify and closely monitor areas where machinery such as pickers and headers breakdown. Weeds 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.

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 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 occurs 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.

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.

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.
- 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 20 mm).

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 a 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.

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. 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.

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?

Options for herbicide resistance testing

Testing a plant population for the presence of herbicide resistant individuals involves growing large numbers of plants in 'ideal' conditions then at particular growth stages applying the herbicide at a range of rates and observing the responses. Generally, seed is collected from the suspect plants and is sent for testing. However the dormancy mechanism in some species, such as barnyard grass, creates problems with this process. It is difficult to get sufficient quantities of seed to germinate uniformly in short time frames. An alternative sampling method is to collect actual plants out of the field for the Quick test. The Quick test process is limited to seedlings/small plants as large numbers need to be collected and posted. Upon arrival they are potted and once re-established, herbicide treatments are applied. In mid-summer conditions plants are less likely to survive the trip than if collected in cooler times of the year. It is recommended to take seed samples from the surviving plants in summer and mark these sites to enable seedling collections in the following autumn or spring if they are needed.

The timeline for obtaining results from sending seed samples can be several months. Results are usually available by the end of April when samples are received before January. When plants are sent for Quick tests results are usually available within 4–8 weeks.

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 Cotton Australia Cotton Map which can be found on the Cotton Australia website. This map will be used by spray contractors, resellers, agronomist and neighbours to identify crops.

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

***my*BMP – www.mybmp.com.au**

CHAPTER 12

Integrated insect and mite management

By **JAMES HILL**

Lewis Wilson and Sandra Deutscher (CSIRO), Robert Mensah and Annie Johnson (Industry & Investment NSW).

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.

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.

KEY POINTS

- 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.
- For further information and support in carrying out integrated insect and mite management refer to the IPM module in myBMP.

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.

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.cottoncrc.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;
- 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.

Crop scouting.

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

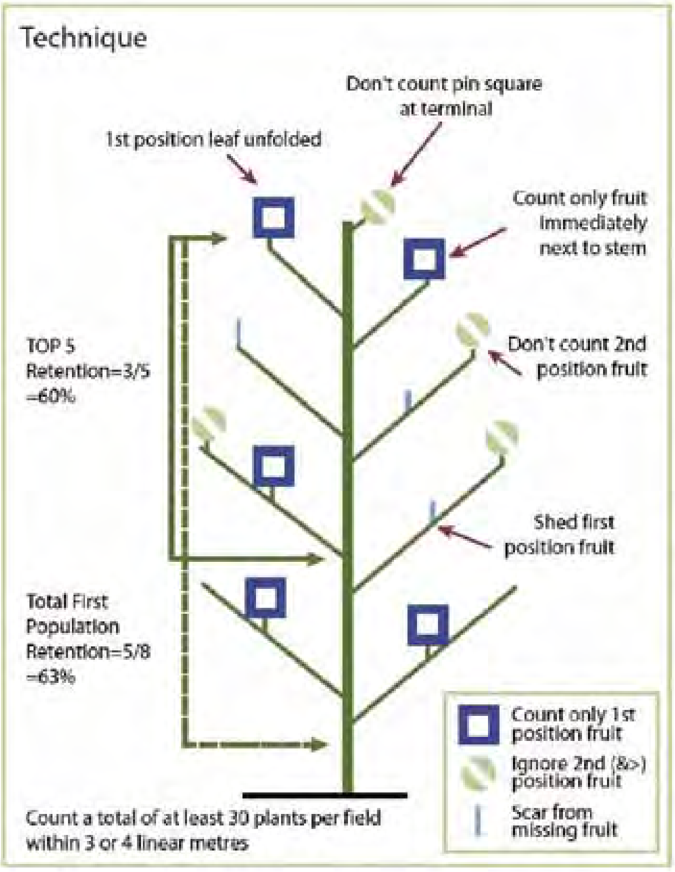
Tool (CDT) uses this knowledge to enable crop managers to check the vegetative and reproductive growth of their cotton crops compared to a potential rate of growth and development. A crop manager can use this information as a prompt to further explore why the crop may not be on track, and manage the crop accordingly. To use the CDT, access CottASSIST through the Cotton CRC website; www.cottassist.cottoncrc.org.au

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.
- Monitor both tipped and non-tipped plants.
- Monitor only the dominant stem, not vegetative branches.

FIGURE 1.
A technique for checking fruit retention.



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 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 10 cm 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.

Faba beans.

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.

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.cottoncrc.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

CHAPTER 13

Disease management

By **SUSAN MAAS**

Developing an IDM strategy for your farm

Stephen Allen CSD, Linda Scheikowski, Cherie Gambley, Murray Sharman and Susan Maas DEEDI

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.

Integrated Disease Management – at the farm or crop level

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 (where available)

- Level of resistance to Verticilium wilt indicated by a higher V.rank,
- Levels of resistance to Fusarium wilt indicated by a higher F.rank.
- Use varieties with good seedling vigour.
- When the Black root rot pathogen is present, use more indeterminate varieties that have the capacity to catch up later in the season.

KEY POINTS

- Cotton is susceptible to a number of diseases that impact on profitability of the crop.
- When a virulent pathogen is dispersed onto a susceptible host and the environmental conditions are suitable then a plant disease develops and symptoms become evident.
- Disease control strategies must therefore focus on the host, the pathogen and/or the environment.
- 'Integrated Disease Management' involves the selection and application of a complementary range of control strategies that minimise losses and maximises returns.
- For further information and support with integrated disease management, refer to the IPM module in myBMP.

- Avoid growing susceptible varieties in fields that contain infected residues.

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.

3. Replanting

Replanting decisions should be made on the basis of stand losses, not on the size of the seedlings.

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 *my*BMP for a template to assist with conducting a disease survey.
- If a suspect plant/s is located, submit suspect cotton plant samples to a plant pathologist for 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.

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.

Boll rot. (Stephen Allen, CSD)

Fusarium wilt. (Linda Smith, DEEDI)

Alternaria leaf spot. (Chris Anderson, I&I NSW)

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 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.
- 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

- Repeated cultivation of cotton can contribute to a rapid increase in disease incidence – especially if susceptible varieties are used.
- 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.
- 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 build up of inoculum and carry over of disease from one season to the next.
- Cotton volunteers and cotton ratoons can significantly increase the risk of disease carry over between seasons.

9. Application of fungicides

- Where appropriate use seed treatments for seedling disease control and foliar sprays for the control of Alternaria leaf spot on Pima cotton.

Verticillium wilt. (Stephen Allen, CSD)

Tobacco streak virus. (Murray Sharman, DEEDI)

Cotton bunchy top. (Stephen Allen, CSD)

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.

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.

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 the use of growth regulators.
- 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

- Fields where soil borne pathogens cause chronic disease in cotton are not 'unhealthy' as healthy cereal crops could be grown in the same field. These diseases are not present because the soil has been mistreated, the presence of the pathogen creates a problem with the health of the plants but not a problem with the health of the soil.

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 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.

FURTHER INFORMATION

Cotton Pest Management Guide

Integrated disease management manual

(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.

CHAPTER 14

Preparing your crop for harvest

By **JAMES HILL**

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 when the crop ceases to produce new fruiting sites. Timing of cutout must consider opportunity for further fruit production (yield) and potential losses in fibre quality and harvesting difficulties. 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. The Last Effective Flower Tool (LEFT) on the CottASSIST website can be used to predict this date using the date of first frost. The LEFT can be accessed through www.cottassist.cottoncrc.org.au

Timing of cutout can be monitored by using Node Above White Flower (NAWF) and be managed by fruit load, irrigation, nutrition or by utilizing a growth regulator. When a crop has 4 or less NAWF it has reached the point where it has achieved 95% of its harvestable yield.

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 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 Fibre Pak) 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 (taken from IPM guidelines)

End of season water requirements can be estimated from the date of the last effective flower which is when

KEY POINTS

- Manage the crop to ensure timeliness of harvest and lessen the risk of weather or frost damage.
- Apply the appropriate harvest aid at the correct time for a timely, efficient and clean harvest.
- Further information and support is available through the Fibre Quality module in myBMP.

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 5-7 mm per day and may decline to around 4 mm 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
- 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
- (Total NACB - 4) x 3 = 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:

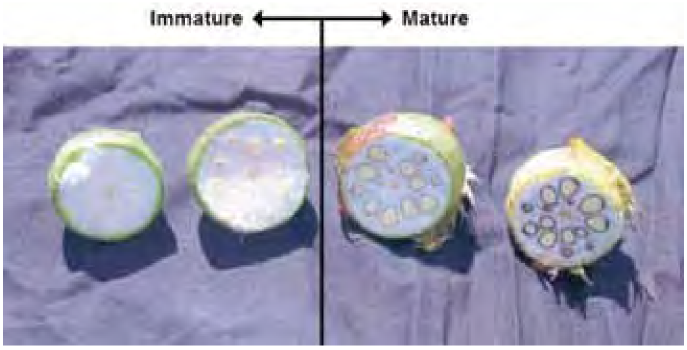
- % bolls open – Crops can be safely defoliated after 60-65% of the bolls are open.. This method is simple and works well in crops with regular distribution of fruit.
- NACB (Nodes above cracked boll) – In most situations 4 NACB equates to the time when the crop has 60% bolls open. This is a useful methodology on crops that are non-uniform in growth, and is less time consuming than % open bolls.

Defoliated cotton ready to be picked.

- 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; 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 on 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.

For more information on managing these pests see the Cotton Pest Management Guide.

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 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. See Table 1 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.

TABLE 1.

Dates of first and last frost for cotton production
(Source of climate data http://www.longpaddock.qld.gov.au/silo/)

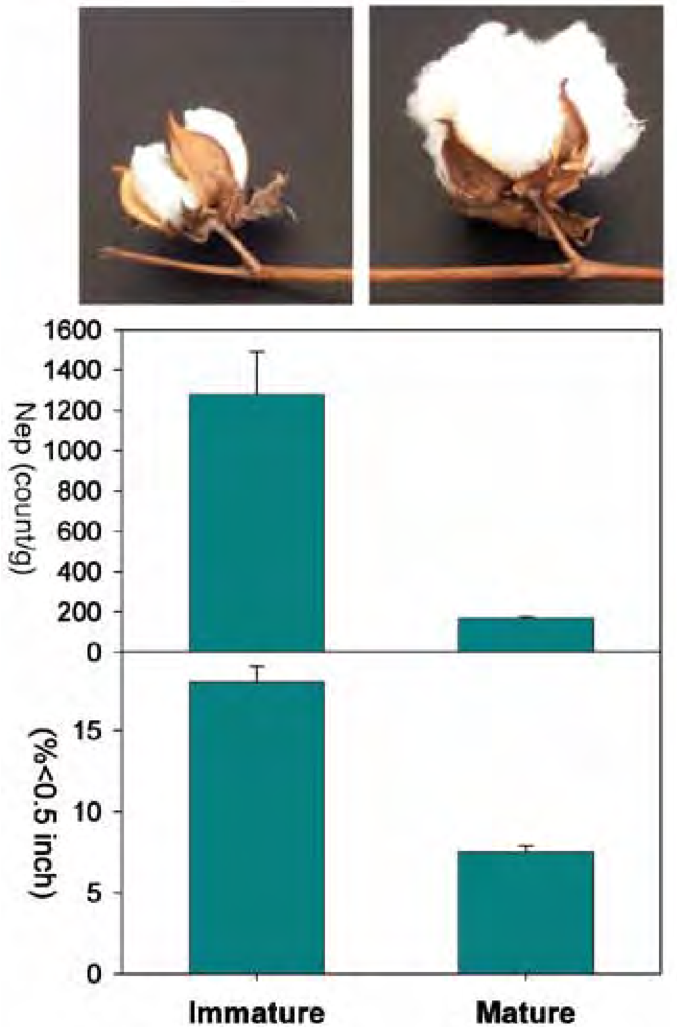
Region	Years of Climate Data	Average Date of First Frost	Date of Earliest Frost Recorded
Emerald	111	9 Jun	23 Apr
Dalby	111	26 May	17 Apr
St George	43	7 Jun	7 May
Goondiwindi	107	2 Jun	23 Apr
Moree	111	28 May	12 Apr
Narrabri	43	25 May	27 Apr
Gunnedah	62	22 May	11 Mar
Bourke	43	12 Jun	10 May
Warren	43	27 May	27 Apr
Hillston	43	17 May	1 Apr

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 harvested. 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

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)



leaves exposes bolls to more direct sunlight, promoting increase temperatures for maturation, and drying and cracking of the boll walls.

Application of harvest aids stem around determining 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 axin 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 these 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, Cyclanillide, Aminomthanane Dihydrogen Textraoxosulfate) - 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 resulting from 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 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 neps increasing.

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

CottASSIST – 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

***my*BMP – www.mybmp.com.au6**

CHAPTER 15

Sponsored by – JOHN DEERE

Harvesting & delivering quality cotton

By **JAMES HILL**

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 in the 2010/11 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

- 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

- May be hard to source contractors due to the expansion in area
- 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

KEY POINTS

- 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

FIGURE 1.
Spindle pickers require regular maintenance to operate at high efficiency.

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 cotton safety 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 other type of harvesting machine is the cotton stripper which is a non-selective, once-over harvester that removes not only the well-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 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 juices 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. This will help detect spindles that have not been wiped or are dirty (causing spindle wrap). If problems occur check water system and 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.

Picker and boll buggy.

- 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 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 being stored 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 degrees Celsius 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

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www.planthealthaustralia.com.au/biosecuritycotton

Best Practice

to 43 degrees Celsius need to be ginned immediately. The temperature of modules harvested at safe storage moistures will not increase more than 5.5 to 8 degrees 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 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

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. (Photos: James Quinn, CSD and Michael Braunack, CSIRO)

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 the top of the module when covered to shed water. 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 stiches. 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.

Keeping good module records

Indentifying 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.

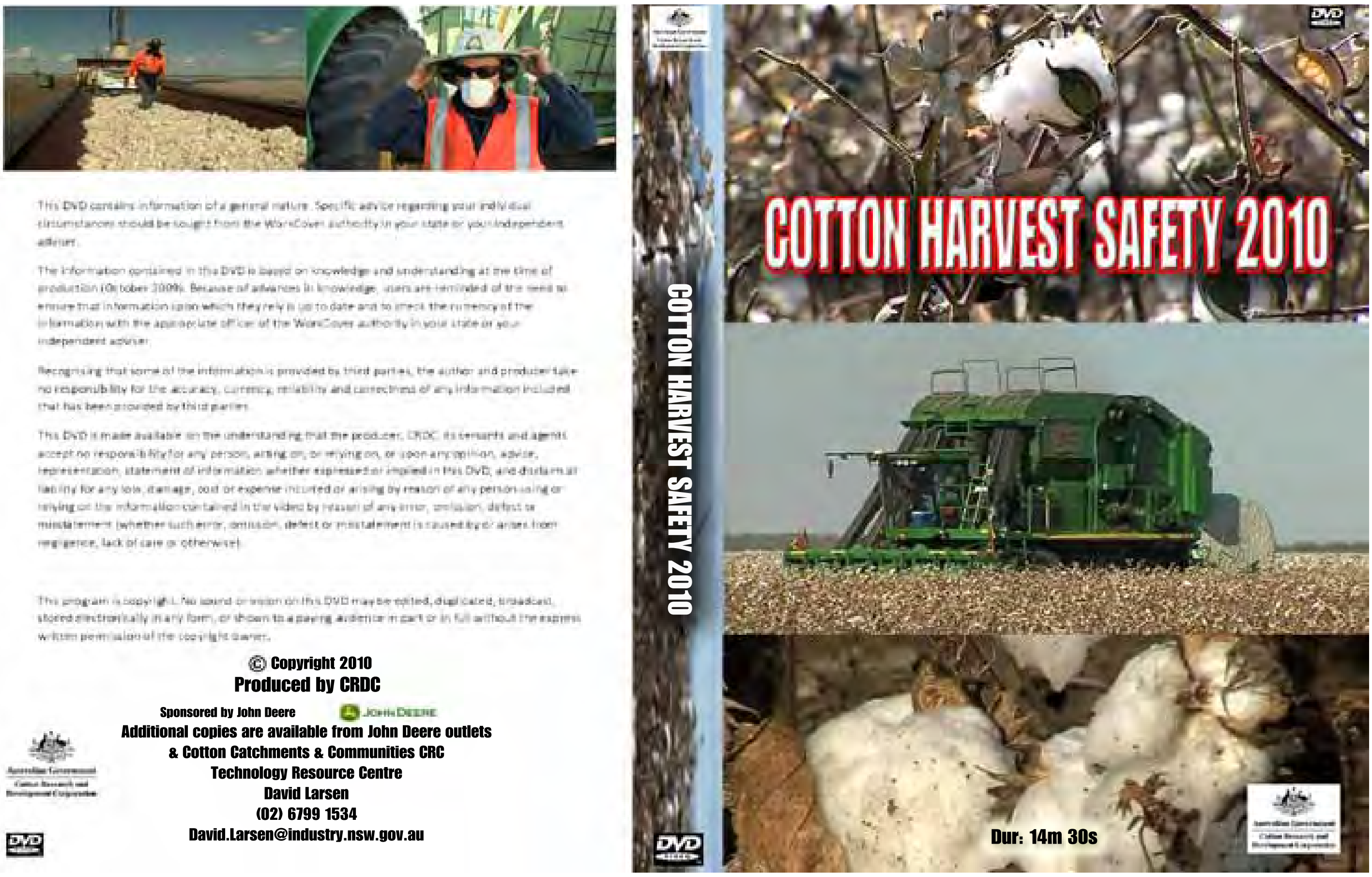
An example module information form can be found in the Fibre Quality module in myBMP.

These guidelines have been extracted from FIBREpak – A Guide to Improving Australian Cotton Fibre Quality.

FURTHER INFORMATION

FIBREpak - http://www.cottoncrc.org.au/content/Industry/Publications/Fibre_Quality/FIBREpak.aspx

***my*BMP – www.mybmp.com.au**



CHAPTER 16

Managing cotton stubble/residue

By **DALLAS KING**

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.

When preparing soil after a dry harvest, the first priority is to deal with the over-wintering pupae of Helicoverpa armigera. They are a major cause of increasing resistance to chemicals. A tillage strategy must be implemented to destroy the pupae by the end of August, while avoiding serious structural damage to the soil and minimising input costs.

Cotton pickers are very heavy, with front axle loads as great as 14 t. However, when the soil profile is dry at harvest, their impact on soil structure is not as great. Wheel damage will not be nearly as severe as when the soil is moist, although wide tyres or dual front wheels may still compact loose beds.

It must be remembered, however, 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 where the self-regeneration capacity of the soil is poor. Such damage may require treatment.

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. If you are contemplating using deep tillage, be aware that the previous cotton crop may not have had enough time to thoroughly dry the soil to an adequate depth before defoliation.

On non-swelling silty soil, however, excessive dust production may be a problem if it is heavily tilled when dry. When dusty soil is re-wetted rapidly, it will have very poor structure.

KEY POINTS

- Pupae control is the number one priority after harvest.
- Controlling volunteer cotton has never been more pertinent.
- The majority of growers utilize mulching & root cutting to manage cotton residues.

Pupae control

Tillage to a depth of at least 10 cm is most likely to kill overwintering Helicoverpa pupae, if all of the very large clods (more than 50 mm wide) in the topsoil have been broken down and rearranged. However, be careful on silty soil where overly aggressive dry cultivation will create too much dust.

For further information on pupae control refer to the Integrated Insect and Mite Management chapter.

'Volunteer' or '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 the Australian Cotton industry.

As has occurred in the Emerald area "volunteer" or "ratoon" cotton now provide a host for exotic pests such as whitefly, aphids, mites and mealy bugs. 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. These will include, slashing / mulching equipment, fertiliser equipment that will follow, soil moisture, bed configuration and irrigation methods.

Cotton stalk management

Crop residues can carry disease, clog tail drains and/or interfere with herbicide incorporation or planting. However, stalk incorporation may improve the amount and quality of soil organic matter. Burning of cotton stalks should be avoided (wherever possible) because of loss of nutrients.

The stalks should be removed soon after harvest, and 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—this can lead to loss of nutrients such as nitrogen. If the cotton disease Fusarium wilt is a problem, it may be necessary to at least partially, disinfect the stalks by exposing them to UV light on the soil surface—burial is likely to aggravate the problem.

Choosing a tillage and/or rotation option

You may find that the crop you have just harvested has partly or wholly fixed the 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. Other fields may not have had such good work done by the crop. Residual compaction may remain; and cracking by rotation crops, and/or deep tillage, may be required to improve yields and profits.

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.

Examine the soil structure using a spade or backhoe pit. If the structure under the plant lines is poor (SOILpak score less than 0.5), consider deep tillage. Where the soil has moderate compaction damage (SOILpak score between 0.5 and 1.5) but does not have good shrink-swell potential (CEC less than 40), deep tillage is also likely to be beneficial, particularly where there is a great danger that new beds will lie over old wheel tracks with their associated compacted zones.

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 1990's when "pull, rake & burn" was quite often the preferred option.

The main processes currently used in the industry include:

- Mulching of stalk above the ground and cutting the root;
- Slashing/mulching of stalk above the ground; and,
- Pull, rake and burn

Generally farmers tend to only pull rake and burn these days when a field is being prepared for lazering

Mulching & root cutting

The majority of the Australian cotton industry has now moved away from the practice of Pull, rake & burn due to some of the negative impacts this system was shown to have on soil fertility. As such the greater majority of growers now utilize mulching & root cutting.

Some of the positives of this system 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; and,
- Residues are mulched back into the soil as opposed to being burnt.

Some of the negatives of this system 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 tertiliser applications;

Herbicide drift on cotton from metsulfuron methyl.

- Machines are generally heavy and horsepower intensive;
- There can be more expense with maintaining machinery due to the extra components; and,
- 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 that common within the industry due to the mulchers being more common and the issues of "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 relazer fields and due to minimal cuts are seeking to avoid stubble becoming an issue with the lazer buckets.

An experiment was conducted at Narrabri over three years (1992-1995) to investigate both stubble management systems in relation to cotton growth, lint yield and tertiliser 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 tertiliser recovery was reduced by 10% where the stubble was removed compared to the retained plots, ie more N tertiliser was lost from the soil where stubble was removed.

A number of growers have adapted the Pull, Rake & Burn system slightly where the cotton stalk is removed via the pulling process but is then mulched by a conventional mulcher rather than raked and burned. This process allows the stubble to be returned into the soil profile during the centre or side busting operations.

FUTHER INFORMATION

SOILpak - http://www.dpi.nsw.gov.au/agriculture/resources/soils/guides/soilpak/cotton

Marketing alternatives

By **JANINE POWELL**

Profitability of a cotton crop is heavily reliant on the price achieved for marketing. 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.

FIGURE 1.
3 1/2 years of cotton prices available to Australian growers.

The ability to 'lock in' a commodity price for some or 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.

KEY POINTS

- 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.

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) include; 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 & discount sheet (for more information about quality see chapter on ginning, classing, quality).

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.

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.


LouisDreyfus Commodities
BRISBANE HEAD OFFICE
P 07 3253 5999 F 07 3257 4131
DALBY WAREHOUSE
P 07 4662 6033 F 07 4662 6044
MOREE WAREHOUSE
P 02 6752 4655 F 02 6752 4568
AgPro SERVICES PTY LTD
CATHY COOK
P 0407 253 784
ANGELA ROTTENBERRY
P 0409 720 160
TOBIN CHERRY
P 0418 244 699
JUANITA PARK
P 0428 753 282
RODNEY ST. CLAIR
P 0438 768 609
www.agproservices.com.au
DUNAVANT GINNING
DALBY GIN
P 07 4669 6988 F 07 4669 6943
EMERALD GIN
P 07 4982 3888 F 07 4982 2988
MOREE GIN
P 02 6752 5188 F 02 6752 4550

Top Line: USD per bale price

Converts price from pounds to bales

$$\text{AUD cash price per bale} = \frac{(\text{USD\$/lb Cotton Futures} + \text{USD\$/lb Basis}) \times 500\ \text{lbs}}{\text{AUD/USD exchange rate}}$$

Converts price from USD/bale to AUD/bale

$$\text{ie AU\$500/bale} = \frac{(0.82 - 0.01) \times 500}{0.81}$$

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 growers 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 (i.e 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/Grower_Marketing_Risk_Handbook.pdf

Cotton CRC:

http://www.cottoncrc.org.au/content/Industry/Publications/Economics/Cotton_Price_and_Marketing.aspx

CHAPTER 18

Ginning

By **MICHAEL BANGE**

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.

A ginner has two objectives:

TABLE 1.
Summary of key post harvest decisions for optimising quality 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.

KEY POINTS

- 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.
- Good communication between growers and ginners is a key factor in assisting this process (see Table 1).

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.

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:

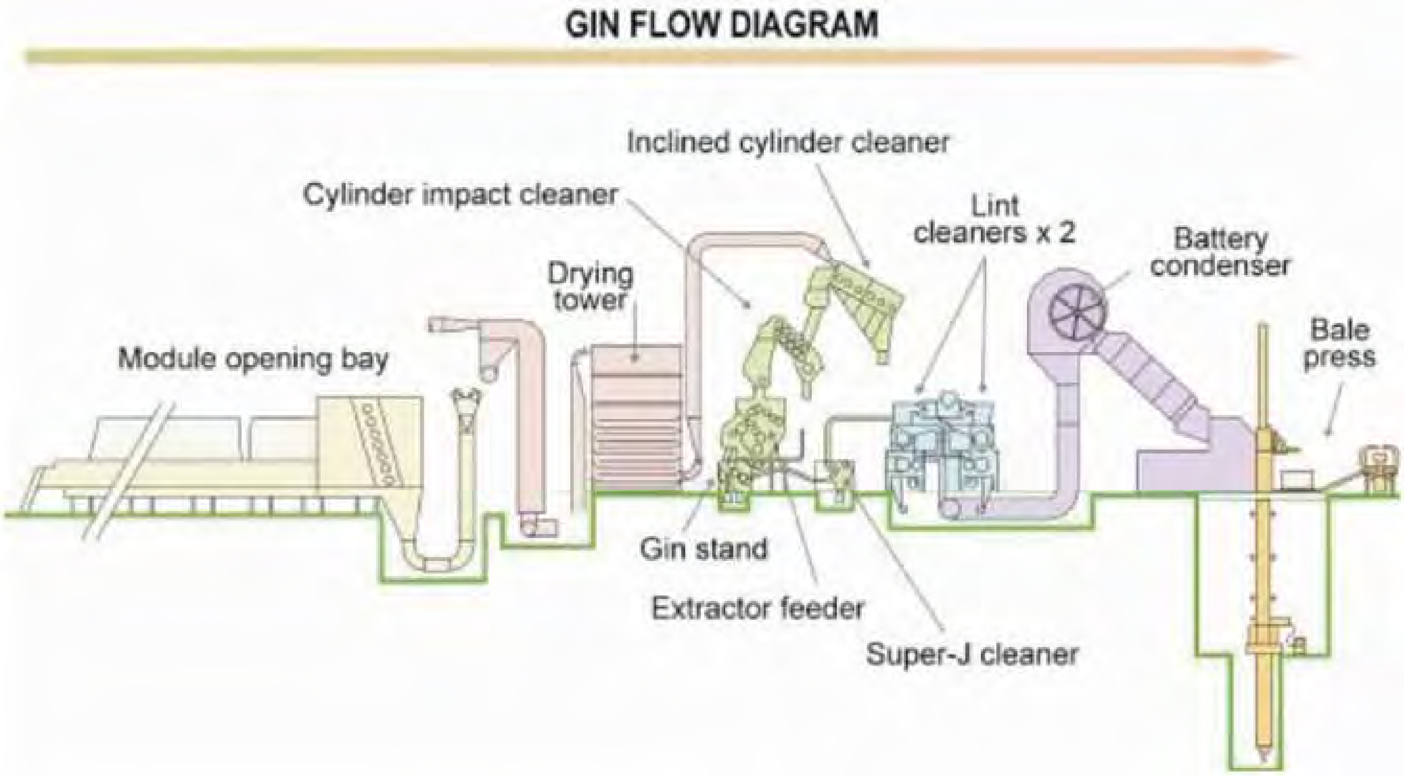
- Ensure defoliation and harvest practices limit trash;
- Contamination is limited; and,
- The size and moisture of the module are appropriate.

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.

At ginning the lint is separated from the seed. Moisture

FIGURE 1.
Gin flow diagram showing cross-sections of machines used in a modern gin to process spindle harvested cotton.



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.

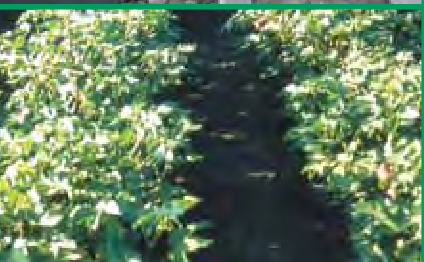
This information has been adapted from FIBREpak chapter 13 – post harvest management.

FURTHER INFORMATION

FIBREpak - http://www.cottoncrc.org.au/content/Industry/Publications/Fibre_Quality/FIBREpak.aspx





CHAPTER 19

Classing

By **JANINE POWELL**

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 put 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 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 chart this page). Premiums and discounts apply for higher and lower grades respectively. These pricing adjustments reflect the change in suitability for the spinning and dying process (see chapter 7, table x '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 (see page x for actual grade descriptions). A colour of 31, is Australian base grade.

KEY POINT

- Classing is a complex process, whilst this chapter gives an overview, a more detailed understanding can be gained from visiting your nearest classing facility.

FIGURE 1.
Interpretation of Base Grade: 31–3–36, G5

BASE GRADE: 31 – 3 – 36, G5

Colour – Leaf – Staple Length, Micronaire

Colour	
Descriptor	**Code**
Good Middling (GM)	1
Strict Middling (SM)	2
Middling (MID)	**3**
Strict Low Middling (SLM)	4
Low Middling (LM)	5
Strict Good Ordinary (SGO)	6
Good Ordinary (GO)	7
Below Grade (BG)	8

Discount applies

Colour	
Descriptor	**Code**
White	**1**
Light Spotted	2
Spotted	3
Tinged	4
Yellow Stained	5

Leaf	
Descriptor	**Code**
Level 1 (least)	1
Level 2	2
Level 3	**3**
Level 4	4
Level 5	5

Staple Length	
Measurement	**Code**
1 inch	32
1 1/32"	33
1 1/16"	34
1 3/32"	35
1 1/8"	**36**
1 5/32"	37
1 3/16"	38
1 7/32"	39

Actual length applies so this table is just an example of possible staple lengths

Micronaire	
Measurement	**Code**
2.4 and below	G0
2.5 through 2.6	G1
2.7 through 2.9	G2
3.0 through 3.2	G3
3.3 through 3.4	G4
3.5 through 4.9	**G5**
5.0 through 5.2	G6
5.3 and above	G7

Leaf

Also known as 'trash' is a measure of the amount of leaf material (from the cotton plant) remaining in the cotton sample. Whist the gin removes the majority of trash, some remains in the sample, remaining trash is removed in the spinning process which reduces lint yield and increases cost. Hence, cotton with high levels of trash attract 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. Micronaire results are grouped on the schedule for premiums and discounts (shown on page X).

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 effect preparation and subsequently grade.

Raingrown cotton normally falls into the acceptable micronaire range, however under hot, dry conditions some 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. (Bange et al. 2009)

Fibre strength

Fibre strength is highly dependant by 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 (see page x). 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, however there may be some differences. P&D schedules often change between seasons and sometimes within the season, the merchant will generally set the seasons 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

$$= \frac{-\$0.08 \times 500}{.85}$$

= AUD -$47.06/bale

Multiple adjustments may apply to one bale of cotton. One adjustment for colour – leaf – staple length, 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

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 2 cm 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 Thuringuensis* 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 11ºC. 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 form 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*, diapauses 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.

E**arliness** 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.

H**abitat 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.

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 irriated 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.

P**lastic 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

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 tertiliser 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 them 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 60 cm deep) attached to a round aluminium frame which is about 40 cm 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 (used to test cotton fibre quality)
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