Australian Dryland Cotton

Production Guide

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Research & Development

Australian Cotton
Cooperative Research Centre

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FOREWORD

Welcome to the Australian cotton industry - and welcome to your new responsibilities – wise advice from a Queensland cotton farmer.

The cotton industry is firmly focussed on both economic and ecological sustainability. That vision embraces a high degree of responsibility - responsibility to neighbours, to the local community, to the broader cotton industry, and to the environment.

As part of its vision, the cotton industry – including dryland farmers – is committed to developing and adopting ***Best Management Practice***. BMP embraces the whole of farm management and includes the adoption of Integrated Pest Management (IPM) techniques, sound resource protection management, and above all, avoiding any detrimental impact on the environment or the community.

Over the last 30 years, research and farmer experience have combined to generate a formidable reservoir of knowledge. New farmers, and particularly raingrown farmers, are now able to tap in to that reservoir.

This reservoir contains knowledge on pest management, safe spraying techniques, regional variety selection, planting configurations and optimum planting windows, crop rotation and soil management, moisture conservation, mechanisation and market risk management.

Luckily the industry is well served by many very professional cotton field consultants. They can help guide and advise you – but remember, the final decisions, and responsibilities, are yours.

The best simple guide for raingrown cotton farmers are the 'Three T's' – Timeliness, Thoroughness and Thoughtfulness. Timeliness and thoroughness are critical in farming and marketing decisions. Thoughtfulness encourages you to think of the consequences of everything you do to your own crop, your own farm, to beyond your fenceline.

The old attitude that 'near enough is good enough' is unacceptable. Not only can it contribute to local and industry problems, it can also hasten the loss of the family farm.

However raingrown cotton does offer good dryland farmers an exciting opportunity to diversify, and possibly to survive economically. Management is demanding but the potential rewards are attractive.

The Australian cotton industry is often seen as a 'young' industry, and one of agriculture's 'success stories'.

Actually cotton has been grown - both as an irrigated, and a raingrown crop - for over 3,000 years. It accounts for well over 40% of all world fibre consumption.

In Australia it is a major contributor to regional development, and to the national economy. Today cotton earns around $1.5 billion in export income, and supports an important value adding domestic textile industry.

Cotton is very much a natural fibre and this again highlights the essential need for wise resource management and sustainable farming practices.

Welcome, and good Luck!

Ralph Schulzé
Executive Director
Cotton Research & Development Corporation

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INTRODUCTION

By Gus Shaw, NSW Agriculture

Cotton (*Gossypium spp.*) belongs to the family Malvaceae, which originated in the hot arid regions of the tropics and sub-tropics of Africa, the Middle East, Asia, Australia, the Americas, Hawaii and certain islands in the South Pacific. Although now modified and adapted to grow in a broad range of environments, cotton does best in areas with a long, hot season.

It has been used as a textile for many thousands of years. Cotton fabrics dating back to 3000BC were found in the Indus Valley in Pakistan and cotton specimens dating from 2500BC were found in Peru.

The plant was introduced into Australia with the First Fleet in 1788 and was first planted in the Sydney area, with disappointing results due to the unfavourable climate. Cotton was farmed commercially for the first time at Moreton Bay in 1840. Early production was confined almost entirely to Queensland.

The modern cotton industry as we know it, commenced in the early 1960s. From modest beginnings in NSW and Queensland, Australia's cotton industry has grown rapidly to become the nation's fourth largest rural export earner (behind wool, meat and wheat). Close to 95% of Australia's annual cotton crop is exported as fibre, netting the country about $1.5 Billion each year in export sales.

Today cotton is grown from Hillston in the south to Emerald in the north by approximately 1500 cotton growers. About 70% of the Australian crop is produced in northern and western NSW with the remainder in southern and central Queensland.

Experimental areas of cotton also exist in a number of locations in northern Australia.

Most is grown under irrigation with dryland plantings fluctuating yearly according to seasonal conditions. In recent good seasons dryland has accounted for up to 20% of the area planted to cotton but less than 10% of the crop production.

A nucleus of experienced growers and consultants has demonstrated that dryland cotton can be profitably produced, providing growers adhere to a fairly strict set of management guidelines. The objective must always be to keep costs to a minimum.

Summary of considerations for growing dryland cotton

- Reliable summer cropping areas
- Paddocks with over 1 metre of subsoil moisture, free of summer weeds, without sticks, stones and too many trees, and away from houses
- Do a cash flow budget
- Finance to grow the crop (costs are typically $600 to $700 / ha)
- Services of a reliable and experienced dryland cotton consultant / agronomist
- Gear-up with machinery, either internally, from contractors or share with neighbours – particularly consider:
    - 3 point linkage tractor
    - planter
    - spray rig
    - harvesting, picking gear
- Discuss growing the crop with experienced growers and consultants and agronomists
- Contact your chemical supplier to budget your chemical needs.

Dryland cotton is an expensive crop to grow and profit margins can easily be eroded unless a tight rein is kept on expenses. Growers should take advantage of every cost saving measure available, without jeopardising crop viability.

The very attractive yields, prices and profits dryland cotton farmers have obtained in the past provide no guarantee for the future. New farmers should approach the crop with caution.

Dryland cotton does not hold the answer to reversing financial problems overnight. It is not a crop for the faint hearted, inexperienced or financially troubled farmer, or for those in climatically unsuitable areas.

Growers considering dryland cotton farming should first have the capital resources required to grow the crop. A commitment by the farmer to a high level of managerial expertise is also necessary. The cotton industry's rapid adoption of advanced production technology bears witness to the high degree of managerial skills required. Successful summer row crop farmers should find the transition to cotton easier.

These notes address in detail the many basic needs for producing a successful crop including:

- budgeting
- machinery
- fallow management
- varieties
- sowing
- nutrition
- herbicide program
- insect management program
- defoliation
- picking
- contractors
- marketing

Figure 1 (opposite) shows a seasonal calender for cotton based on a crop water use chart from NSW Agriculture.

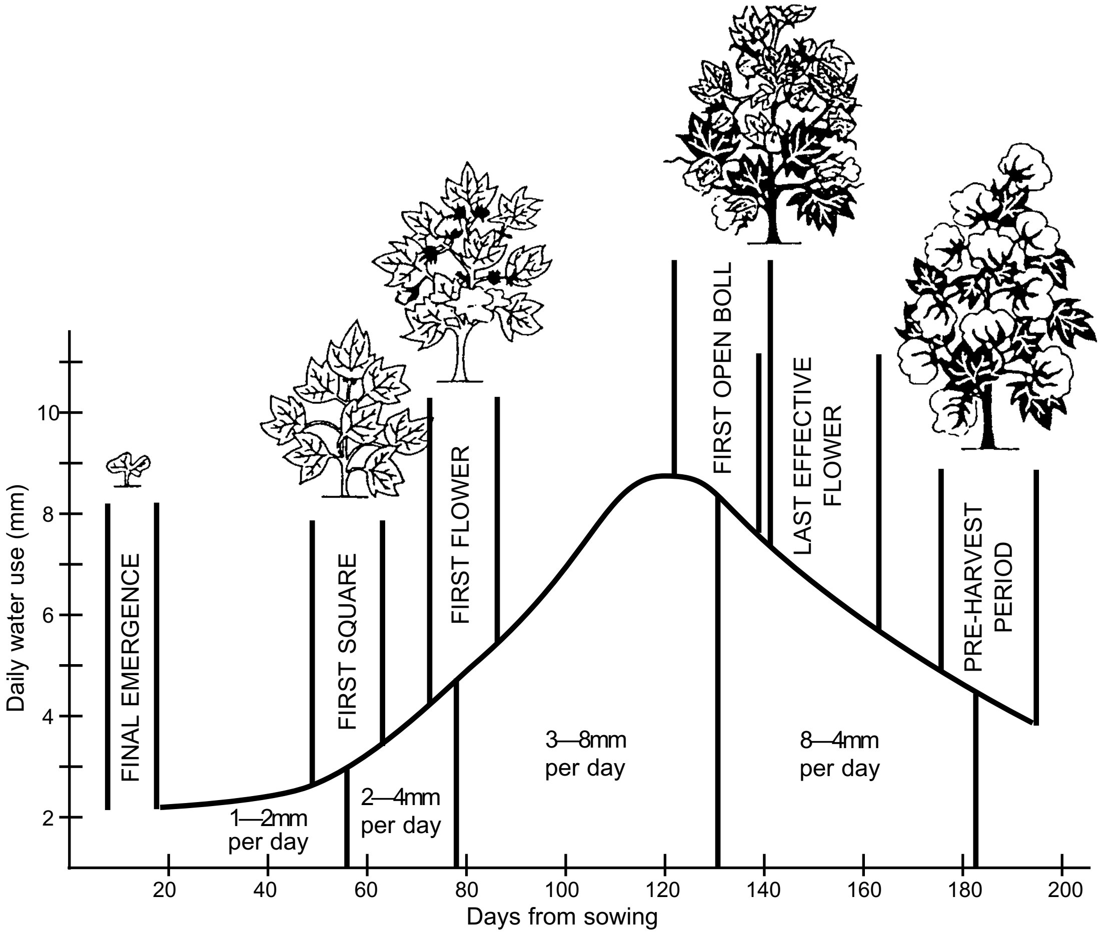
Other cotton references include:

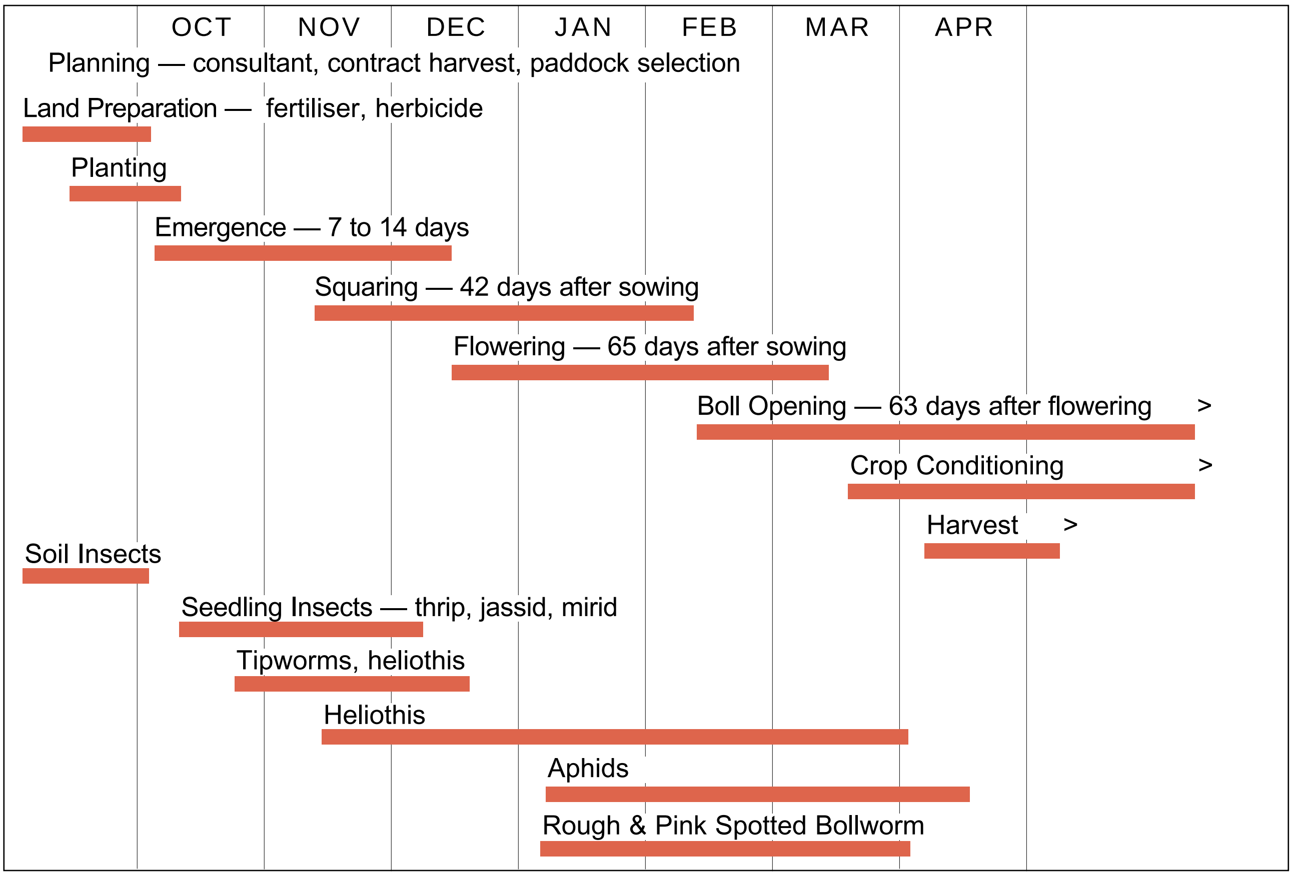
- New Crop Management Notes 2002/2004 Summer Edition (CD-ROM)
- WeedPAK
- MachinePAK
- SprayPAK
- SoilPAK
- EntoPAK
- NutriPAK
- The Cotton Pest Management Guide, NSW Agriculture, Agdex 151/680
- Cotton Pest & Beneficial Guide
- CottonLOGIC
- Temperature Requirements for Cotton
- Soil and Nutrient Management of Irrigated Cotton, AgFact
- Weed & Disease Management of Cotton, AgFact
- Improving Soil Structure with Gypsum, AgFact
- Update of regulations on the use of Endosulfan
- Insect Pest Management Guidelines
- Insect Pest Management Short Course
- Integrated Disease Management Guidelines

If you are a new grower or have changed address details including email, contact the Australian Cotton CRC Technology Resource Centre (David Larsen) on 02 6799 1534, or David.Larsen@agric.nsw.gov.au, so you can be included in industry wide mailouts.

Access to a lot of information can be obtained through the publications section of the Cotton CRC website at: www.cotton.crc.org.au

Figure 1. Cotton Seasonal Calender *(Water Use Chart courtesy NSW Department of Agriculture)*





BEST MANAGEMENT PRACTICES

By Allan Williams, CRDC

The Best Management Practices ("BMP") Manual helps cotton growers identify and manage the areas of their farm that carry risks to the environment and human health, particularly those relating to pesticide use. The BMP Manual contains modules covering the following areas:

- Application of pesticides
- Storage and handling of pesticides
- Integrated pest management
- Farm design and management
- Farm hygiene

Modules under development applicable to dryland farming include occupational health and safety, and petrochemical storage and handling.

Each module contains a best management practice booklet that explains what the best practices are for that issue, and why they are important. Legal responsibilities are also noted.

The booklet is followed by self-assessment worksheets that are used to help identify and assess your operations against recommended best practices. Further sources of information are listed that can be used to plan and implement best practices for issues identified during the self-assessment process.

Once you have identified the areas on your farm that require attention through the self-assessment process, action plans are developed, and blank forms are included.

A separate *Introductory Booklet and Guide to Use* is included with the BMP Manual to help you work through it.

EXAMPLES OF BEST PRACTICES

Pesticide Application

The core best management practice for safe and responsible pesticide use is to develop a pesticide application management plan. This will help ensure that everyone involved in pesticide application has a clear understanding of their responsibilities, and it also helps identify the risks associated with pesticide use so that controls to minimise those risks can be put in place.

A pesticide application management plan will cover areas such as pre-season and in season communications, appropriate weather conditions, product and equipment selection and use, and record keeping.

KEY POINTS:

- **Find out about the BMP Manual from your local Cotton Australia or Extension officer.**
- **Contact your neighbours and discuss plans.**
- **Ensure lable compliance when using farm chemicals. This includes weather monitoring and recording of data.**

Pesticide Storage and Handling

This sections deals with the issues relating to pesticide transport, storage and mixing, as well as disposal of used containers and left over pesticides. Practices detailed include the choice of location for a storage facility, the requirements for the storage itself such as ventilation and spill containment, and mixing and loading techniques.

Integrated Pest Management (IPM)

The BMP Manual contains information on IPM – refer Insect Management chapter in this publication

Farm Hygiene

The main focus of this section is preventing the spread of diseases and weeds (particularly fusarium wilt). It also includes information on how to manage diseases if they are found on your farm. Areas covered include detection and notification, machinery and equipment cleaning and destruction of fusarium wilt affected plants.

EXAMPLES OF SPECIFIC BEST PRACTICES FOR DRYLAND COTTON

Nearly all the information contained in the BMP Manual is relevant for dryland cotton production, although the farm design and management module has sections specific to dryland and irrigated cotton growing. Some of the issues addressed in the dryland section include:

- Minimising run-off and erosion
- Controlling run-off
- Using buffer zones

WHERE TO GO FOR HELP

The Cotton Australia Grower Services Manager for your region can provide you with a copy of the BMP Manual, and help you work through it. Contact Cotton Australia's office in Sydney on 02 9360 8500 for more information.

DRYLAND COTTON POTENTIAL & RISK

By Mike Bange, CSIRO Plant Industry

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. Members of the CSIRO Cotton Research Unit at Narrabri have used long-term climatic records (90 to 100 years) and the OZCOT crop simulation model developed by Brian Hearn to study the prospects for dryland cotton production in the major cotton growing 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 while initially developed for irrigated cotton production has now been developed to include simulation of dryland crops. Brian Hearn has tested the model extensively across data collected from dryland experiments conducted in different regions with solid, single and double skip row configurations (**Figure 2**).

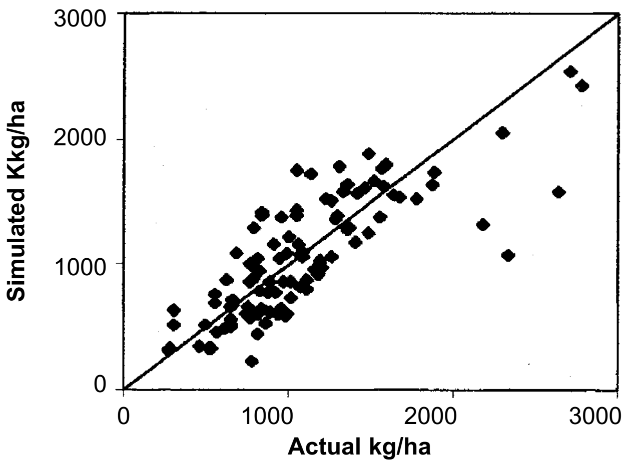


Figure 2: Simulated yield using the OZCOT crop simulation model versus actual crop yields from dryland cotton experiments exploring row configuration (R2 = 0.64). Data provided to Brian Hearn by Bruce Pyke and Phil Goyne.

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**).

KEY POINTS:

- **The crop simulation model "OZCOT" and the Southern Oscillation Index (SOI) are both very useful risk management tools**

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)
Gunnedah	405	255
Wee Waa	387	251
Bellata	394	253
Moree	390	253
Croppa Creek	396	258
Goondiwindi	421	275
Dalby	489	319
Biloela	534	373
Emerald	496	363

Simulating Dryland Cotton Production

The information presented in this article uses the OZCOT crop simulation model developed by CSIRO Cotton Research Unit.

Some assumptions used in this study were:

- Cracking clay soil storing 200mm of available soil moisture in 1.5m profile.
- Crops sown on October 15.
- Row spacing set at 1m.
- Established population of 7 plants per metre of row.
- Yield is potential yield. It does not account for the affects of soil nutrient limitations, insect pests, diseases, weeds, and management failures.
- The model does not simulate the effects of climate and management on fibre quality, which is another important consideration when choosing to grow dryland cotton.

Sowing Opportunities

The risk of failing to obtain a sowing opportunity was assessed for three, 30 day periods starting September 15. A sowing opportunity was defined in terms of adequate soil moisture and temperature:

25mm (1”) of water in top 100mm (4”) soil.
18°C mean temperature for 3 consecutive days

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

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

Region	Probability of failing to sow (%)			
	Sep 15 to Oct 15	Oct 15 to Nov 15	Nov 15 to Dec 15	Overall Sep 15 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: Solid row configuration - Effects of three starting soil moistures on potential yield (bales/ha, nitrogen non-limiting) and variability of yields expressed in terms of probability of exceedence.

Region	One Quarter of a Full Profile			One Half of a Full Profile			Full Profile		
	Mean	80%	20%	Mean	80%	20%	Mean	80%	20%
Breeza	**1.4**	0.4	2.7	**2.1**	0.8	3.0	**2.1**	0.8	3.1
Wee Waa	**2.4**	0.8	4.0	**3.8**	2.4	5.2	**3.9**	2.5	5.2
Bellata	**2.3**	0.6	4.0	**3.8**	2.3	5.6	**3.9**	2.5	5.8
Moree	**1.9**	0.4	3.2	**3.5**	2.0	4.8	**3.7**	2.2	4.9
Croppa Ck	**2.2**	0.5	3.8	**3.9**	2.2	5.3	**4.0**	2.4	5.5
Goondiwindi	**2.2**	0.4	3.8	**3.7**	2.1	4.9	**3.9**	2.4	5.0
Dalby	**3.9**	1.7	5.8	**4.9**	2.8	6.5	**4.9**	2.8	6.6
Biloela	**3.9**	1.9	5.7	**5.1**	3.3	6.4	**5.1**	3.5	6.4
Emerald	**3.3**	1.1	4.9	**4.5**	2.9	6.1	**4.8**	3.0	6.2

Table 4: Single skip row configuration - Effects of three starting soil moistures on potential yield (bales/ha, nitrogen non-limiting) and variability of yields, expressed in terms of probability of exceedence.

Region	One Quarter of a Full Profile			One Half of a Full Profile			Full Profile		
	Mean	80%	20%	Mean	80%	20%	Mean	80%	20%
Breeza	**1.2**	0.3	2.2	**1.8**	0.7	2.9	**1.9**	0.7	3.0
Wee Waa	**2.4**	0.6	4.0	**3.9**	2.6	5.3	**4.0**	2.7	5.3
Bellata	**1.8**	0.3	3.3	**3.6**	2.6	4.6	**3.8**	2.9	5.1
Moree	**1.9**	0.3	3.1	**3.7**	2.3	4.8	**3.8**	2.5	4.8
Croppa Ck	**2.2**	0.3	3.8	**3.6**	2.5	5.0	**3.9**	2.7	5.0
Goondiwindi	**2.1**	0.4	3.9	**3.7**	2.4	4.8	**3.8**	2.6	4.7
Dalby	**3.5**	1.7	4.9	**4.2**	3.0	5.5	**4.3**	3.0	5.7
Biloela	**3.0**	1.5	4.4	**4.6**	3.3	6.0	**4.7**	3.5	5.9
Emerald	**3.0**	1.0	4.4	**4.2**	2.7	5.4	**4.4**	2.9	5.3

Potential Yield and Soil Moisture at Sowing

The risk of failing to break even can be reduced if growers sow with greater soil moisture. Fallowing between crops is a strategy to increase subsoil moisture and will reduce the risk of crop failure and increase average yield. **Tables 3 and 4** show that in all regions at least half a profile of soil moisture will increase yield significantly when the crop is sown on October 15. It also shows that it is not essential to have a full profile for achieving higher average yields. If the crop is established it requires minimal soil moisture prior to first flower, thereby increasing the chance of rainfall providing soil moisture useful for later crop growth. In some cases a full profile increased the chance of waterlogging and reduced average yields. For these simulations nitrogen was considered to be non-limiting to compare potential yield.

The advantages of a long fallow to restore soil moisture must be balanced against the loss of production when a successful crop could have been grown on the fallowed country.

For each region average potential yields along with yields associated with 'Probability of exceedence' values are presented in **Table 3** for solid row configurations and **Table 4** for single skip row configurations. 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.

Time of sowing

In all regions average yields, using typical nitrogen application rates, were less when crops were sown before September 30 (**Figure 3**). The latest sowing date where there was no penalty to average yield was November 30 for all regions with the exception of the Darling Downs, where yield reduced after the 15th November. In many cases, noticeably the Macintyre, Gwydir and Namoi valleys, a slightly later sown dryland crop has the potential to produce higher yields by allowing the crop to capture more rainfall when the crop needs it most. 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.

Skip Row Planting

Skip row (single or double) is usually considered when there is a higher risk of inadequate in-crop rainfall or when the amount of moisture in the soil profile at planting is less than favourable. It also allows for more soil moisture to be available at the end of the season to allow the bolls to develop higher quality fibre (A factor not considered in these analyses). A comparison of solid plant yields with single skip row yields showed that a skip row configuration performed better in those environments that had less average rainfall and more variable rainfall (**Table 5**). The disadvantage of skip row however, was that in years where rainfall was high the solid plant configuration can produce substantially higher yields. This is reflected in the higher average yields for some regions for solid configurations shown in previous tables.

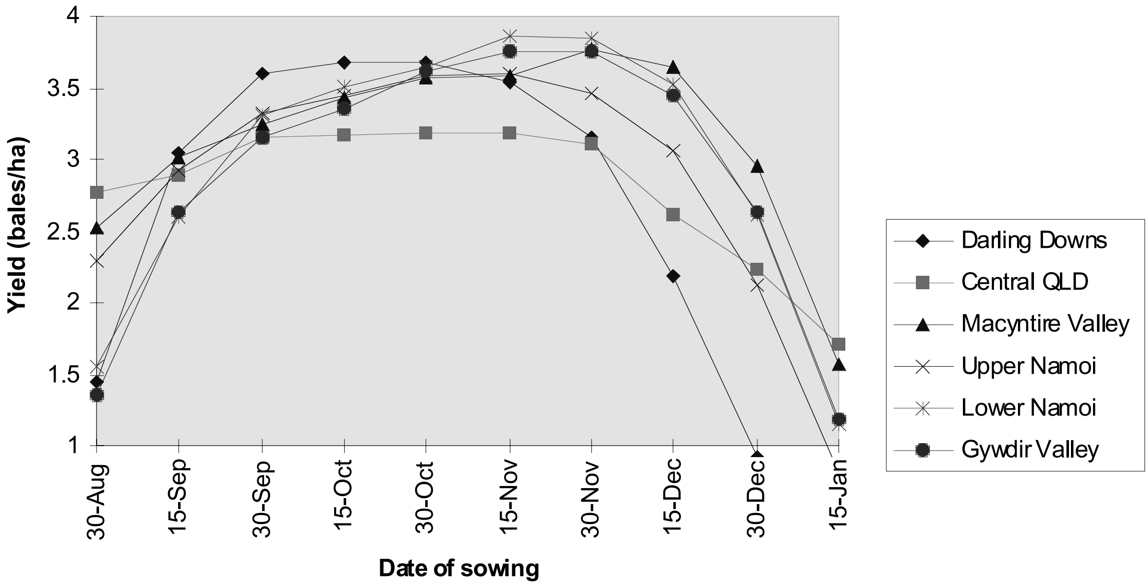


Figure 3: Change in expected crop yield with sowing date. Yields have been simulated using a typical commercial nitrogen rate for each region.

Table 5. Proportion of years where a single skip row configuration performed better than solid plant configurations. Results tsken from OZCOT simulations using a soil with 200mm of available soil moisture in 1.5m profile.

Region	Proportion of years better than solid plant (%)
Wee Waa	68
Moree	74
Bellata	74
Croppa Creek	57
Goondiwindi	56
Dalby	76
Biloela	51
Emerald	60

More detailed information on the issues that need to be considered when choosing between solid and skip row configurations is presented later in this manual.

Nitrogen Fertiliser

The addition of nitrogen fertiliser improved average potential yields in all regions. Increased averages were mainly due those years where rainfall was high and crops were able to better utilise this nitrogen. Yields showed little response to nitrogen in low rainfall years in any region

Seasonal Climate Forecasts to Assess Risk

Over the last decade the development of seasonal climate forecasts, based on the El Niño - Southern Oscillation (ENSO) phenomenon, has introduced the possibility of allowing for climate variability, rather than passively accepting the risks it generates. Adjusting management in the light of probable future weather trends offers considerable opportunities for managers of agricultural systems.

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

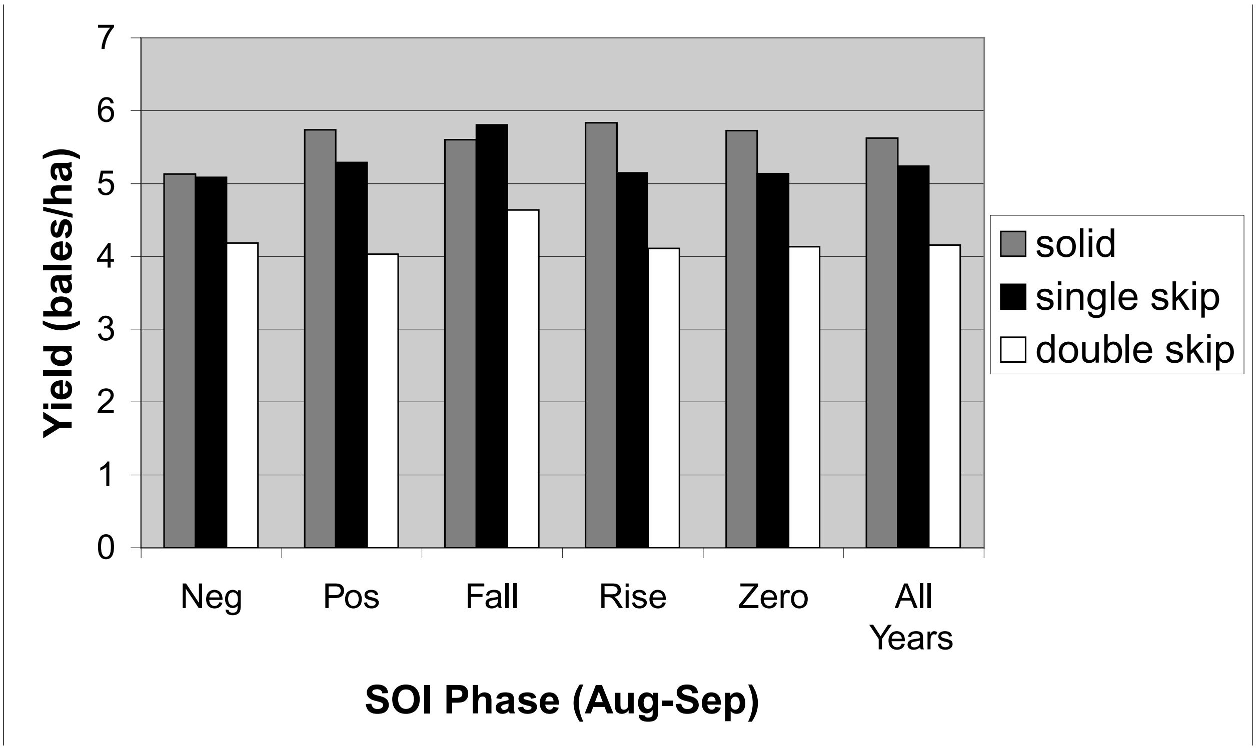


Figure 4: Forecasted average dryland cotton yields (simulated using OZCOT) at sowing time (October) for different row configurations with half a profile of soil moisture at sowing in Dalby for different phases of the SOI (Aug-Sep).

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 be associated with the SOI phase at the time of forecast such as land preparation or sowing time. Simulation models, when used in conjunction with the SOI can therefore provide opportunities for growers to tailor their management decisions more appropriately to the impending seasonal conditions. Information of this nature has been used successfully to assist wheat growers in Southern Queensland in their variety choice and nitrogen management based on expected rainfall and predicted risk of frost.

Figure 4 illustrates how the SOI and OZCOT can assist dryland growers to decide whether to plant on a skip row or a solid configuration. This decision is more difficult in areas where rainfall is widely variable from year to year. While selection of a planting configuration in dryland production involves many factors, the first is to determine the average yield potential of the various row configurations considering the available soil moisture. When this has been estimated, the economics of different configurations can be assessed. Comparative analysis of profitability of the different planting configurations should take into account cotton prices and the differences in growing costs between regions. The following scenario demonstrates how seasonal forecasts, based on the SOI phases, can also assist growers with this decision.

In this example the grower has half a profile of available soil moisture (128mm) and wants to decide on a row configuration for dryland cotton production. The scenario is for a Dalby grower sowing a cotton crop in early October in a soil with a soil water holding capacity of 255mm. The OZCOT model was used firstly to simulate yields for each year in the climatic record for the different row configurations. Given that the grower has to make a planting decision in October, each estimate of yield

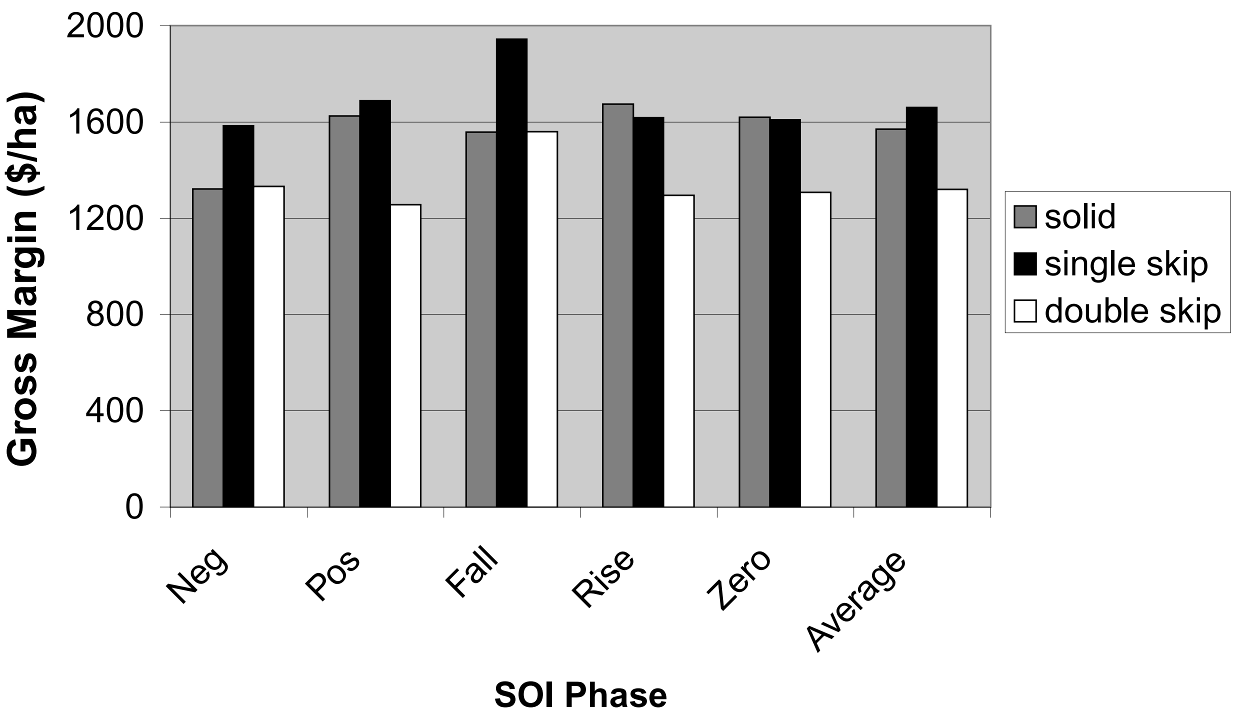


Figure 5: Predicted average gross margins for different row configurations with half a profile of soil moisture at sowing in Dalby for different phases of the SOI (Aug-Sep). (returns $450/bale, costs solid $1249, costs single skip $963, double skip $762).

derived using the historical records was categorised into one of the five groups using the SOI phase derived from the change in SOI during the August to September period during the year of sowing. Each group was then averaged for the different row configurations (**Figure 4**).

At Dalby averaged across all years the results show that the solid row configuration has the highest potential yields, followed by the single skip then double skip configuration (**Figure 4**). However, if the SOI phase at planting is taken into account the results give a slightly different prediction of yield. The solid configuration is better when the SOI phase is constantly positive, rapidly rising and zero, but single skip was just as good if the SOI phase is rapidly falling or negative. Double skip was lowest across all phases. The average yields for each of the SOI phases can be translated into gross margins (**Figure 5**).

In this specific example for Dalby where the crop was sown into half a profile of moisture there appears to be a significant financial advantage in sowing single skip configurations when the SOI phase is constantly negative or falling at sowing. When the SOI phase is positive, rapidly rising or zero there is no clear advantage in sowing either solid or single skip row configurations. For this example there seems to be no advantage in sowing double skip. Again no consideration of the impacts of skip row configurations on fibre quality and associated returns are considered.

In addition to row configuration other management options to reduce risk or seize opportunities 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.

Useful Web Sites for Seasonal Climate Forecasting

http://www.dnr.qld.gov.au/longpdk/

http://www.BoM.GOV.AU/

http://www.BoM.GOV.AU/silo/

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 issues relating to the management and financial considerations of dryland cotton and different row configurations in dryland cotton production follow in this manual.

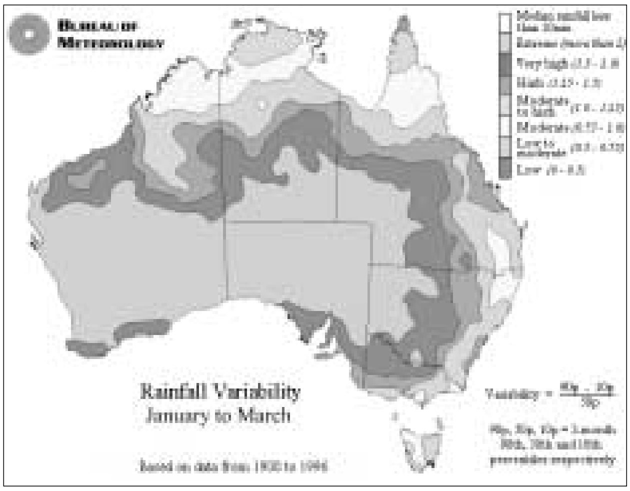
The growing of dryland cotton is subject to relatively large risk, not only in achieving yields but also because costs are a high proportion of income. Therefore the potential and risks associated with dryland production need to be calculated. Crop simulation models such as OZCOT provide a useful tool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

IMPACT OF RAINFALL VARIABILITY

By Bob Ford, Deltapine Australia &
Neil Forrester, Deltapine International

Dryland cotton production is affected by many uncontrollable climatic factors, the number one being rainfall. Australia has predominantly less rainfall than many other countries, making dryland cropping at times, a risky proposition. **Figure 6** illustrates rainfall variability and risk across the cotton growing regions. A majority of dryland crops are grown in areas that have moderate to high variability

Figure 6: Rainfall variability across Australia. REF: www.bom.gov.au



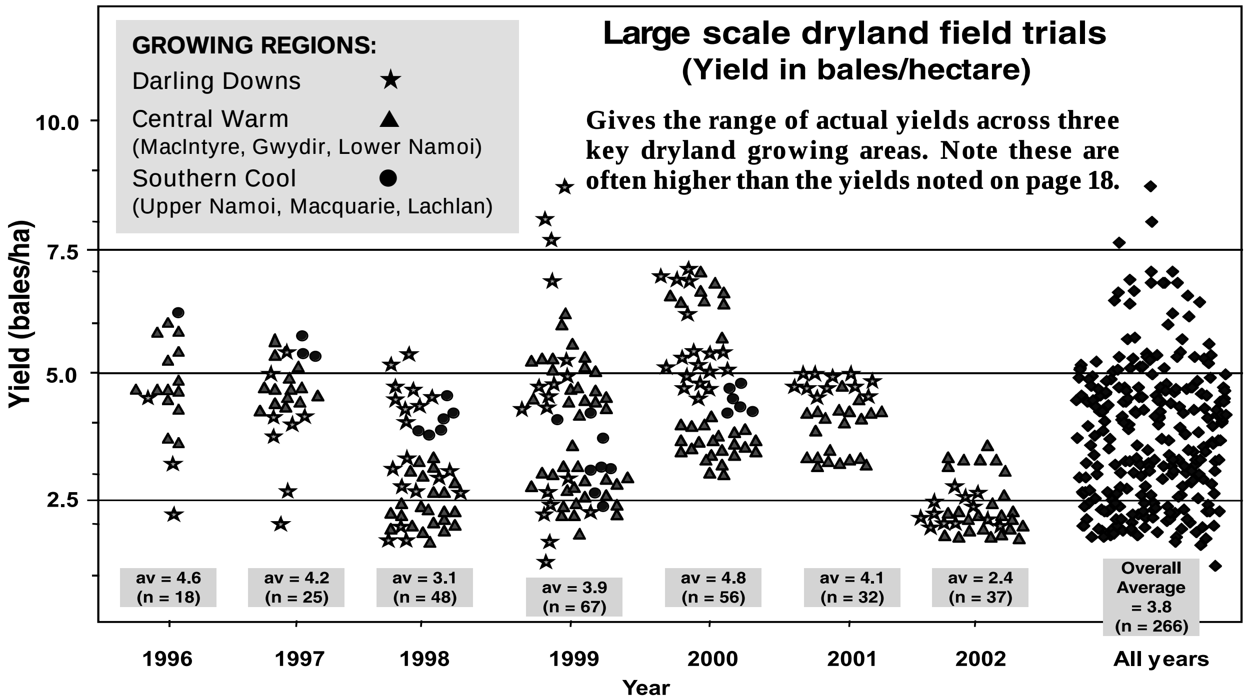
> **KEY POINTS:**
>
> - **Grow strong, deep rooting, indeterminate varieties.**
> - **Evaluate variety trials over a number of years for yield, micronaire and fibre length.**
> - **Be aware that rainfall and water shortages may impact on fibre quality and yield.**
> - **There are many options to manage rainfall variability**

in rainfall from January to March, which are the most important months in determining both yield and fibre quality of dryland cotton.

Unlike many other crops, cotton has a great ability to compensate for drought stress due to its indeterminate growth pattern which allows it to survive dry periods and then to exploit good growing conditions when they occur. In the advent of good rainfall after a previous dry period, the plant will respond by putting on more fruiting positions on the second and third positions on lateral branches and by putting on more main stem nodes.

In dry years, both yield and quality parameters are affected depending on stored soil moisture and in-season rainfall. Because of the variability of rainfall across most cotton growing regions, dryland yields can fluctuate widely. **Figure 7** demonstrates the yield

Figure 7: Yield results for 7 years testing of a range of varieties in large scale dryland field trials, indicates to growers the range of yields that they can expect under varying rainfall conditions.



performance of DPA & CSD varieties over seven years of testing in Deltapine's large scale dryland field trials.

Yield variability follows rainfall variability. In years where rainfall varies across regions like in 1998 and 1999, yields also have a greater range. The very dry year in 2002 resulted in the lowest yields in 7 years of testing.

Dry conditions in January and February not only lead to poorer yields but also can impact on fibre quality.

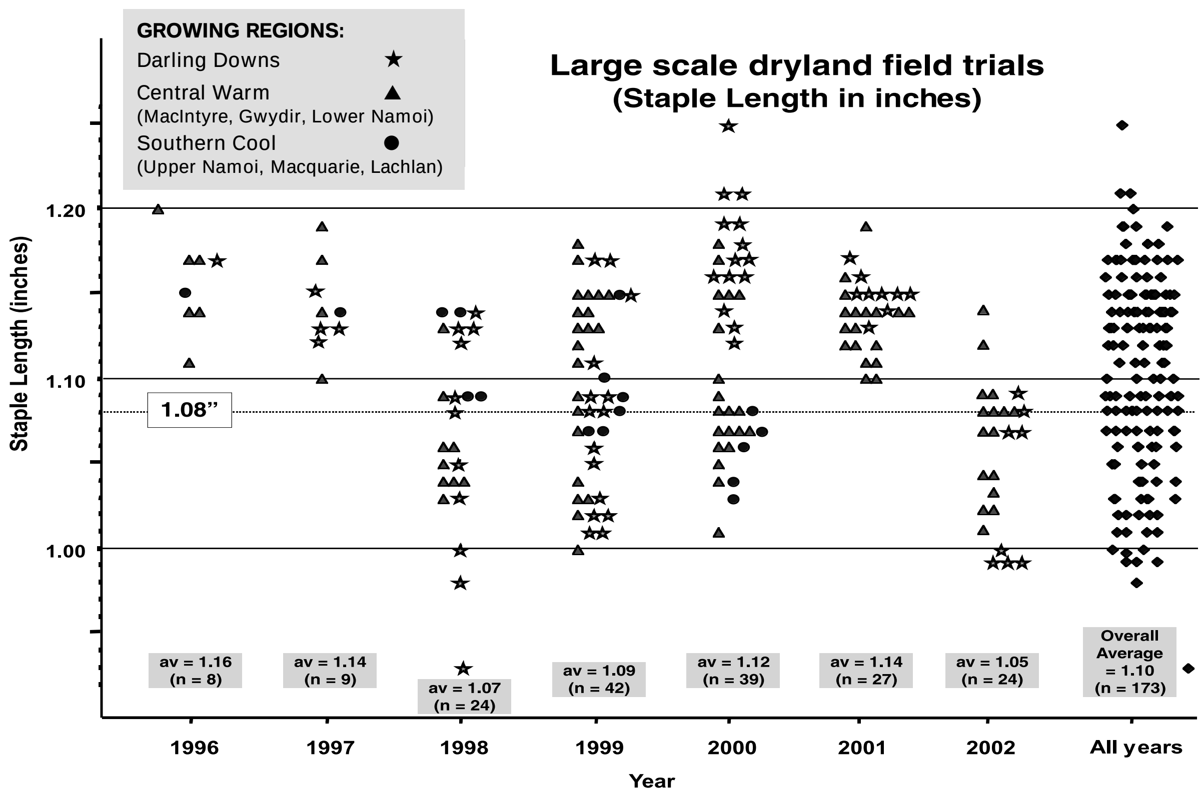
Extremely high or low temperatures during the elongation phase of fibre development (the first 16-20 days), may result in shorter fibre. Fibre length is also decreased by severe water stress and potassium deficiency. Both of these decrease the internal water pressure, thus limiting the expansive force for fibre elongation. **Figure 8** shows the impact of variable rainfall on the fibre length over seven years of Deltapine dryland variety trials.

In the years (1996, 1997, 2000 & 2001) where rainfall was adequate, yield and fibre length were acceptable but in 1999 in a drier season, fibre length averaged 1.09 inches over the 42 entries which is just above penalty range for length. In 1998 the fibre length averaged 1.07 inches over 24 entries and in 2002 the fibre length averaged only 1.05 inches over 24 entries. These figures are in penalty range (<1.08 inches) and would attract discounts. Invariably, the lower yielding years (1998, 1999 & 2002 with 3.1, 3.9 & 2.4 bales/ha, respectively) have a trend towards shorter fibres and hence more length penalties. These years had less rainfall events during peak flowering between January and February across most regions.

With fibre length being reduced due to the impact of reduced summer rainfall, other quality problems can also occur. If good conditions then return, such as a rainfall event in late February, the supply of carbohydrate is reactivated. If rainfall occurs during the second stage of fibre thickening (after fibre length has already been set), the extra cellulose is directed to the fibre cell wall with thicker daily rings of cellulose being set down into the central lumen, resulting in high micronaire.

Water stress often causes high micronaire because boll retention is very sensitive to water stress, but fibre thickening is much less sensitive. Boll retention is reduced when the water stress level drops below -19 bars (afternoon xylem pressure potential); fibre thickening and the elongation are not affected until the severe level of -26 bars is reached. When a plant experiences water stress, it sheds young bolls, leaving the older bolls on the

Figure 8: Fibre length results for 7 years testing of a range of varieties in large scale dryland field trials.



plant with ample carbohydrates to fully thicken the fibre.

The opposite of this can occur when the crop runs out of moisture in the second stage of fibre formation (20-40 days after flowering) when fibres are thickening. Length may not be affected but due to reduced supply of carbohydrate for fibre thickening, the fibres are thinner resulting in low micronaire. **Figure 9** shows the impact of variable rainfall on micronaire over 7 years of Deltapine dryland variety trials.

In 2002 where yields were low and fibre length was short, micronaire shows a trend towards higher than normal results. Consequently some discounts for high micronaire would occur.

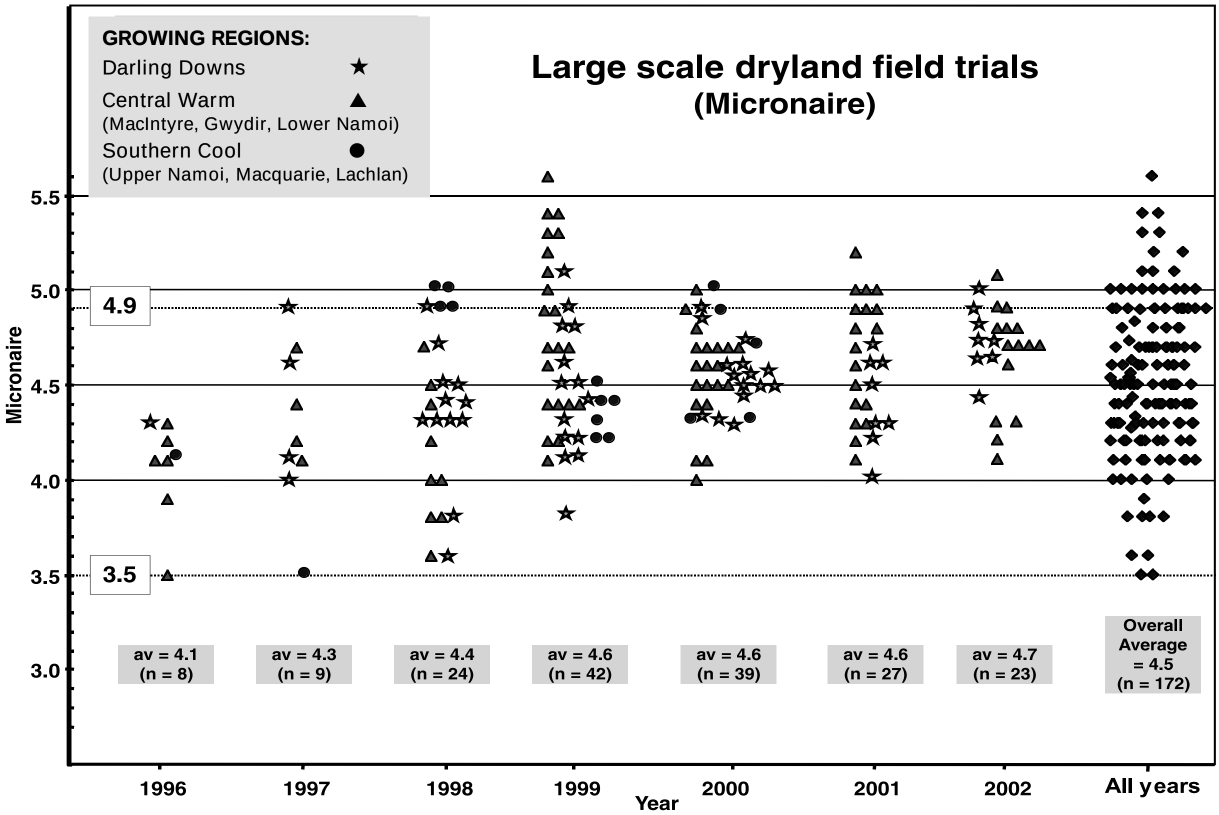
Other reasons for high micronaire are varietal and also loss of top positions in the crop which predominantly have lower micronaire than the rest of the plant. These top position bolls can help reduce the overall crop micronaire, once all positions in the crop are averaged.

Other affects on quality due to rainfall variability occur in strength, short fibre index and colour class but occur less frequently and have fewer penalties. The major affects of climate variability are on yield, staple length and micronaire, as previously mentioned.

Generally it is difficult to manage for in-seasonal changes in climate and hence the importance of selecting the right variety with a number of advantages in the dryland system:

- Varieties that have a deep rooting ability that is predominantly strongly indeterminate.
- Varieties that have good water use efficiency.
- Varieties that have yield stability over years.
- Varieties that have a stable micronaire over years.
- Varieties that have longer fibre length.

Figure 9: Micronaire results for 7 years testing of a range of varieties in large scale dryland field trials.



By John Marshall & Rob Eveleigh, CSD & Mark Hickman, NSW Agriculture

DARLING DOWNS

Darling Downs crop statistics show significant variation in annual mean yield across the region since the dryland cotton industry began expanding in 1983. Land set aside in rotation for dryland cotton has increased nearly every year although failure of planting rain prevents this area being realised each year. A combination of good average price at planting, a full profile of moisture and timely planting rain would see a potential planted area of around 50,000 hectares.

The top yields on the Darling Downs come from the deep basaltic alluvial soils on the Central Downs, and the Pirrinuan/Jimbour area of the Northern Downs. However, most of the region is capable of producing 5-6 bales/ha if everything goes well. Long-term averages for the region show the Northern Downs with 3.25 bales/ha and the Central Downs with 4.00 bales/ha.

Dryland commercial yields range from a low of 0.5 bales/ha up to 9.75 bales/ha with the full range experienced across the area in some years. Low yields are generally associated with early planted crops grown on a marginal profile of soil moisture, experiencing hot dry conditions in late December/early January, or late planted crops suffering heavy heliothis damage and then an early frost. High yields are associated with timely mid-season rainfall, adequate late season heat, and low Heliothis pressure.

Data from 12 Dryland farms entered in the Darling Downs Cotton Growers Association (DDCGA) crop competition in the 1998/99 and 1999/00 seasons showed a yield range of 4.5–8.0 bales/ha with an average of 6.3 bales/ha. Mean variable cost was $1147/ha and the mean Gross Margin $1815/ha. These 2 seasons were very rewarding for most growers, combining above average yields with good bale price.

Estimating crop yield is improving with crop modelling. The Agricultural Production Systems Research Unit (APSRU) based at the Department of Primary Industries (DPI) in Toowoomba uses the CSIRO OZCOT Agricultural Production Simulator (APSIM) model. APSIM assists growers in choosing between various crop options and planting times available for summer crop planting.

KEY POINTS:

- **Variability in yield, both within and between seasons in all major production areas is characteristic of dryland production**
- **Conservative rotations, stubble management, minimum tillage, controlled traffic, fallow management, timely planting & improved varieties all contribute to improvements in long term average yields.**

CENTRAL QUEENSLAND

With the exception of 2000/01 season, dryland cotton production in Central Queensland has been severely limited with a series of dry years, with an average planting of 2000-3000 hectares only. Yields in most seasons have ranged from 2.5- 3.25 bales/ha although the 1999/00 season produced yields of up to 8 bales/ha. The combination of timely rain and an attractive bale price produced an 8000-10000 hectare planting in 2000/01, with an average yield of about 2.75 bales/ha.

MOREE DISTRICT

The majority of dryland cotton crops are grown in eastern areas around Croppa Creek, Pallamallawa, Terry Hie Hie and Gurley. The further west the crop, the less reliable the rainfall and crop yields.

District yields over the last five years have ranged from 0.5 bales/ha to 7.5 bales/ha. This variability in yield emphasises the potential risks and rewards of growing dryland cotton. The overall average for east Moree is in the range of 2.0 bales/ha to 3.0 bales/ha (0.8 to 1.2 bales/ha).

Practices which reduce the risk of crop failure include 3 in 1 rotations, stubble retention and minimum tillage controlled traffic fallow management.

A range of row configurations are used by growers across the district with high yielding crops produced from all row configurations. However, given the variability in crop yields, single or double skip is generally recommended. Skip row has the advantage of reducing both production costs and the risk of total crop failure and producing poor quality fibre (lint).

LOWER NAMOI VALLEY (Edgeroi/Bellata)

Dryland cotton yields in the Narrabri Shire have averaged about 2.8 bales/ha over the last 10 years, although average yields for the last 5 years exceed this figure. This may reflect the adoption of better growing technology.

Crop yields show large variation from year to year. Lint yields as low as 0.9 bales/ha and as high as 7.5 bales/ha have been obtained by growers in Narrabri Shire. This variation reflects timeliness of summer rainfall and crop agronomy. The risk of achieving lower than average yields can be minimised by timely planting and good fallow management.

UPPER NAMOI VALLEY (Gunnedah)

The boom in dryland cotton production occurred in the 1990-91 season, with the bulk of the expansion occurring in the Boggabri / Mullaley district. Genuine mixed cropping growers adopted dryland cotton with moderate success. During the next three years yields were highly dependent on the rainfall events, 1990–91, 92-93 and 93-94 seasons average yields were 3.5, 4.3 and 2.5 bales/ha respectively.

As with any short season area, temperature limitations define the production boundaries of that region. Consequently precise crop management is required to maximise both earliness and yield potential.

The principle row configuration used is solid plant. However, growers are investigating the option of sowing single skip cotton. The aim of single skip is to help reduce input costs, especially insecticide and biotechnology licensing fees. The negative component of single skip cotton that can extend the growing season required to produce an adequate yield.

Rainfall in the Upper Namoi is considered adequate for solid plant cotton, however the reliability and timeliness of these rainfall events is the critical factor. Like all summer cropping areas, a cotton crop requires well timed rainfall plus at least 90-100cm of stored subsoil moisture at planting. This combination has resulted in a long term average yield of 3.28 bales/ha (1.3 bales/ac) for the district.

A combination of conservation tillage practices and varietal improvements have led to a slight but continual improvement in long term yield average. Okra leaf cotton varieties have provided a major advancement for dryland cotton, as these varieties exhibit improved water use efficiency and better canopy penetration for insecticides. Unfortunately, in recent seasons, there has been an increase in trash discounts from merchants and based on current crop management practices many growers are changing back to conventional leaf varieties to avoid these grade discounts.

In conclusion, dryland cotton within the Upper Namoi has become both a main revenue source for growers and a viable rotation crop for the general mixed farming community.

SOUTH WEST QUEENSLAND

The area of dryland cotton has steadily increased in the South West broadacre farming lands of Waggamba, Tara and Murilla Shires over the last 4-5 years. Yields have averaged about 2.75 bales/ha, ranging from 1.0 - 4.5 bales/ha. Much of the cotton is planted into long fallowed no-tilled winter cereal stubble – a proven technique for maximising soil moisture storage. A depth of 90 cm of soil moisture at planting is important to maximise the probability of at least breaking even.

SUMMARY

A summary of potential dryland cotton yields for the major regions in Queensland and NSW is presented in **Table 6**.

Table 6: Dryland cotton yield potential (bales/ha).

Region	Long Fallow		Short Fallow	
	Average	Range	Average	Range
Darling Downs	3.6	2.0–8.0	2.25	0.4–3.0
Moree	2.5	1.0–5.0	n/a	n/a
Central QLD	2.5	1.75–7.0	1.5	0.4–2.5
Lower Namoi	3.0	0.9–6.5	n/a	n/a
Upper Namoi	3.0	2.0–6.8	2.0	1.0–4.0
Sth West QLD	2.75	1.75–4.0	n/a	n/a

By Fiona Scott, NSW Agriculture

GROSS MARGINS

Crop gross margins representing the difference between gross income and the variable costs of producing the crop are presented for solid and skip row plantings in the major cropping areas.

These budgets are a guide only, and individual growers should draw up their own.

It is advisable to only make comparisons of gross margins between enterprises which use similar resources. If major changes are being considered, more comprehensive budgeting techniques (that include overhead costs) are required to indicate the real profitability situation.

Gross margins do not take account of the following factors:

Risk: gross margins can show the proportion of costs in relation to income, but don't consider price and yield risk. The sensitivity tables following the budgets help to illustrate the effects of yield and price variations.

Cashflow pattern: **Figures 10** have been developed as a guide to show when costs may be incurred during the season.

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 reliable estimates of such costs.

Assumptions used in these gross margins include:

- Average season yields following a winter cereal and long fallow
- Selection of pesticides 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.

KEY POINTS:

- **Budgeting is a necessary ongoing process on all cotton farms**
- **Lint price per bale is critical to profitability**
- **Caution should be exercised when entering into forward contracts**

Listing of brand or chemical names in the budgets does not imply a recommendation of those brands/chemicals.

- An average to high number of insecticide applications using a soft approach to maintain predators.
- 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 NSW Agriculture's *Farm Budget Handbook 2001 Winter Crops*: Northern NSW- Summer Crops and the NSW Agriculture AgFact (M2.6) on machinery calculations (www.agric.nsw.gov.au)
- Chemical prices are those estimated at January 2001. For further information on chemicals, refer to NSW Agriculture's "Cotton Pest Management Guide".

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 processors and merchants. Details should be discussed with appropriate personnel.

Payment timing depends on the type of contract. Many arrangements pay 60 to 75 percent in the July after ginning, with final payments in September and December.

DRYLAND COTTON BUDGETS

Compiled by Fiona Scott, NSW Agriculture, 02 6763 1156

The gross margin budgets are intended to provide a guide to the relative profitability and an indication of management operations involved in different dryland cotton enterprises.

Budgets are calculated using crop yields for the region that are consistent with the operations given, forecast commodity price, current input costs 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 seasonal conditions, but also by the individual farm characteristics such as soil type, crop rotation, and management.

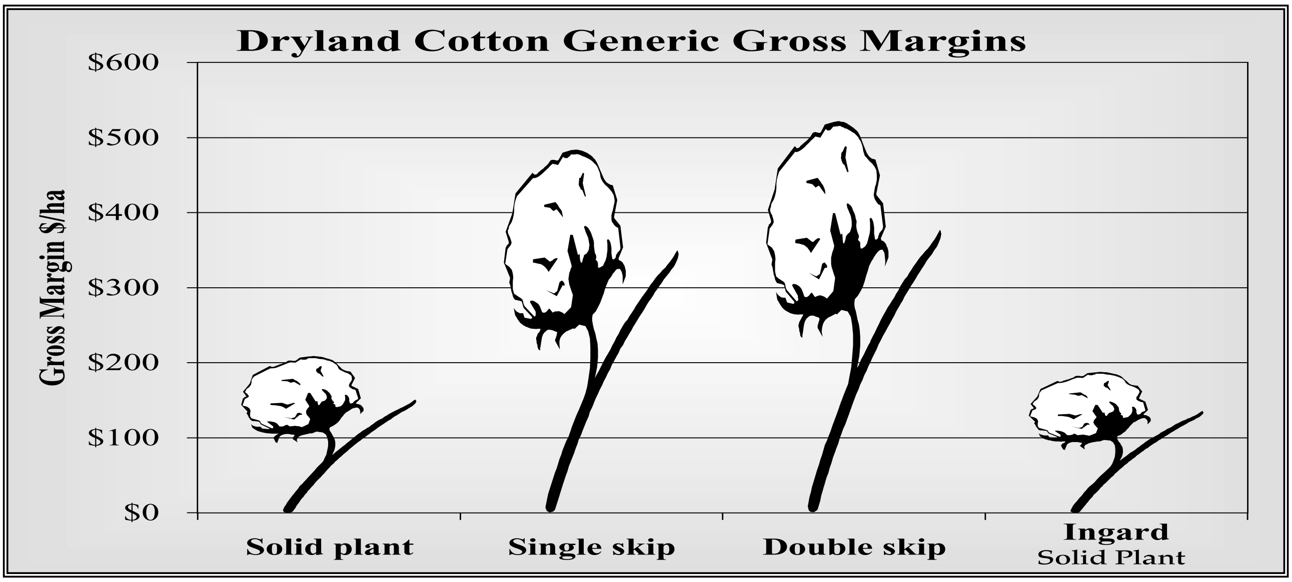
Consequently, it is strongly recommended that the budgets be used as a GUIDE ONLY and should be changed to take account of movements in crop prices, changes in seasonal conditions and individual farm characteristics.

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.

Refer to the NSW Agriculture website (www.agric.nsw.gov.au) for downloadable specialised cotton budget forms in Excel format. Look for "Farm Forms" under Farm Business and Trade -> Economics Publications.

Acknowledgements: Thanks to Gus Shaw and Mark Hickman of NSW Agriculture.

Table 7: Dryland cotton generic gross margins.



Dryland Crop	Yield (bales/ha)	Income	Costs	Gross Margin	Costs as a % of income	Est. Breakeven yield
Solid plant	3.00	$1,466	$1,257	$209	86%	2.92
Single skip	2.70	$1,316	$831	$485	63%	1.70
Double skip	2.50	$1,219	$696	$523	57%	1.43
Ingard-Solid Plant	3.00	$1,463	$1,274	$188	87%	2.61

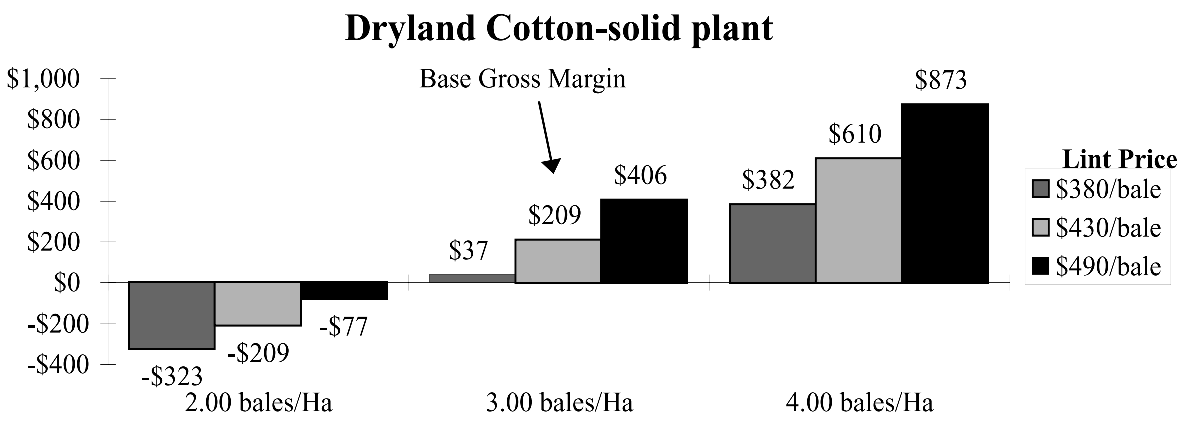
Table 8: Dryland cotton solid plant.

INCOME:	**Lint:**	3.0	bales/ha at	$430	*/bale (at gin)................................ $1,290
	Seed:	1.1	tonnes/ha at	$160	/tonnes (at gin).............................. $176
				A. TOTAL INCOME $/ha:	**$1,466**

Variable costs:

CALENDAR OF OPERATIONS:		Machinery			Inputs				**Total**
			Cost	Total		Band	Cost	Total	**Cost**
Operation	Month	hrs /ha	$/hour	$/ha	Rate/ha	Width	$	$/ha	**$/ha**
Cultivation - chisel plough	Jan	0.14	40.46	5.66					**5.66**
Cultivation - chisel plough	Apr	0.14	40.46	5.66					**5.66**
Cultivation - scarifier	Jun	0.17	34.46	5.86					**5.86**
Herbicide - glyphosate ground spray	Aug	0.03	31.46	0.94	0.7 L	100%	5.23	3.66	**4.60**
Wetter - non-ionic surfactant	Aug	with above			0.2 L	100%	6.43	1.29	**1.29**
Cultivation - scarifier	Sep	0.17	34.46	5.86					**5.86**
Herbicide - trifluralin ground spray	Sep	with above			2.1 L	100%	7.81	16.40	**16.40**
Planting - precision planter	Sep	0.16	38.79	6.21					**6.21**
Planting - seed	Sep	with above			10 kg	100%	6.18	61.80	**61.80**
Urea incorporation	Sep	with above	40 kgN		87 kg	100%	0.47	40.89	**40.89**
Herbicide - fluometuron+prometryn ground spray	Sep	with above			3.0 L	40%	12.65	15.18	**15.18**
Herbicide - metolachlor ground spray	Sep	with above			2.0 L	40%	17.24	13.79	**13.79**
Crop insurance	Sep							51.31	**51.31**
Cultivation - inter-row	Oct	0.17	37.13	6.31					**6.31**
#'Insecticide - fipronil 200g/L	Nov	0.03	31.46	0.94	0.06 L	40%	300.00	7.20	**8.14**
Herbicide - shielded sprayer	Nov	0.10	35.46	3.55					**3.55**
Herbicide - glyphosate ground spray	Nov	with above			2.0 L	40%	5.23	4.18	**4.18**
Insecticide - BT	Dec	0.03	31.46	0.94	2.0 L	50%	22.90	22.90	**23.84**
Insecticide - amitraz EC	Dec	with above			2.0 L	50%	13.32	13.32	**13.32**
Herbicide - shielded sprayer	Dec	0.10	35.46	3.55					**3.55**
Herbicide - glyphosate ground spray	Dec	with above			2.0 L	40%	5.23	4.18	**4.18**
Growth Regulator - mepiquat -ground	Jan	0.03	31.46	0.94	0.5 L	75%	28.85	10.82	**11.76**
Insecticide - emamectin	Jan	0.03	31.46	0.94	0.7 L	60%	96.00	40.32	**41.26**
Insecticide - spinosad 480g/L	Jan	0.03	31.46	0.94	0.2 L	75%	320.00	48.00	**48.94**
Insecticide - deltamethrin	Feb	aerial spray		12.50	0.7 L	100%	24.85	17.40	**29.90**
Insecticide - amitraz	Feb	with above			2.0 L	100%	13.32	26.64	**26.64**
Insecticide - chlorpyrifos	Feb	aerial spray		12.50	5.0 L	100%	9.35	46.75	**59.25**
Insecticide - ethion + zeta-cypermethrin	Feb	with above			2.2 L	100%	17.79	39.14	**39.14**
Insecticide - thiodicarb WP/WG	Mar	aerial spray		12.50	1.2 kg	100%	53.00	63.60	**76.10**
Defoliant - thidiazuron	Apr	aerial spray		12.50	0.25 L	100%	142.32	35.58	**48.08**
Defoliant - crop oil	Apr	with above			2.0 L	100%	2.48	4.96	**4.96**
Defoliant - salt defoliant-aerial	Apr	aerial spray		12.50	2.0 L	100%	1.25	2.50	**15.00**
Contract Spindle picking									
and module building	May	contract		$280/hr @ 1.0 hrs/ha					**280.00**
Contract Module lifting	May	contract		$50 /module @ 17 bales per module					**8.82**
Contract module cartage to gin	May	contract		$3.35 /km @ 50 km from gin					**29.56**
Ginning charges	May	contract		$60 /bale					**180.00**
Consultant	May	contract							**45.00**
ACF levy and Research levy	May			$3.75 /bale					**11.25**
								B. TOTAL COSTS $/HA:	**$1,257**
								C. GROSS MARGIN $/HA:	**$209**
								Costs as a percentage of income:	**86%**

Table 9: Sensitivity table, solid plant.



LINT YIELD bales/ha	SEED YIELD t/ha	At Gin Price $380 /bale $140/t	$405 /bale $150/t	**$430 /bale $160/t**	$460 /bale $168/t	$490 /bale $176/t	Lint price Seed price
1.5	0.5	(502)	(460)	(417)	(368)	(319)	
2.0	0.7	(323)	(266)	(209)	(143)	(77)	Gross
2.5	0.9	(143)	(71)	0	82	164	Margin
3.0	**1.1**	37	123	**209**	308	406	($/ha)
3.5	1.3	217	317	418	533	648	
4.0	1.4	382	496	610	741	873	
4.5	1.6	562	690	819	967	1,115	

AGRONOMIC NOTES-SOLID PLANT

Insects: Various insecticides are available for early season pest control (eg thrips, wireworms) but not included here, since they are not always required.

Fipronil is applied for mirid control.

The selection of insecticides is highly dependent on the insect spectrum, growers should be aware this is a generic program and selection of products should be made with IPM strategies in mind. Refer to the "Integrated Pest Management Guidelines for Australian Cotton". Rotation of insecticides should be followed as per industry strategy, which changes each year due to changes in insect resistance to chemicals from season to season. For more detailed information, see the NSW Agriculture "Cotton Pest Management Guide 2001-2002". Always read chemical labels and follow directions, as it is your legal responsibility to do so. Use of a particular brand name does NOT imply recommendation of that brand by NSW Agriculture.

Weeds: To reduce the likelihood of herbicide resistance, rotate herbicide groups and weed management techniques.

Management: This budget is for a long fallow following a winter cereal crop.

Fertiliser: Fertiliser requirements should be based on paddock records and soil tests.

Defoliant: Thidiazuron has been used as the primary defoliant in this example. Good conditions are required to get the best performance. The kind of defoliant used depends on the moisture status of the plant. An additional chemical is sometimes used to aid boll opening.

MACHINERY ASSUMPTIONS: Tractor: 170 KW PTO (230 HP) and 200 KW engine (265 HP) Machinery costs refer to variable costs of: fuel, oil, filters, tyres, batteries and repairs.

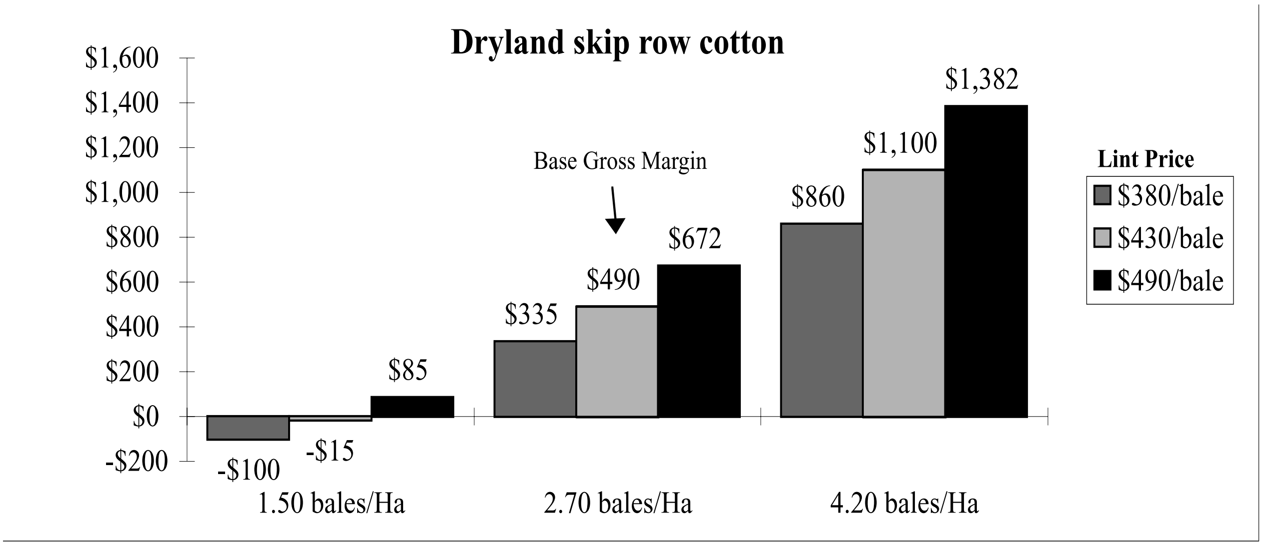
Table 10: Dryland cotton single skip.

INCOME:						
	Lint:	2.70	bales/ha at	$430	*/bale (at gin)..	$1,161
	Seed:	0.97	tonnes/ha at	$160	/tonne (at gin)..	$155
					A. TOTAL INCOME $/ha:	$1,316

Variable costs:

CALENDAR OF OPERATIONS:		Machinery			Inputs				Total
Operation	Month	hrs /ha	Cost $/hour	Total $/ha	Rate/ha	Band Width	Cost $	Total $/ha	Cost $/ha
Cultivation - chisel plough	Jan	0.14	40.46	5.66					**5.66**
Cultivation - chisel plough	Apr	0.14	40.46	5.66					**5.66**
Cultivation - scarifier	Jun	0.13	37.96	4.93					**4.93**
Herbicide - glyphosate CT ground spray	Aug	0.03	31.46	0.94	0.7 L	100%	5.23	3.66	**4.60**
Wetter - non-ionic surfactant	Aug	with above			0.2 L	100%	6.43	1.29	**1.29**
Cultivation - harrow	Sep	0.13	37.96	4.93					**4.93**
Herbicide - trifluralin ground spray	Sep	with above			2.1 L	100%	7.81	16.40	**16.40**
Crop insurance	Sep							26.32	**26.32**
Planting - precision planter	Sep	0.16	38.79	6.21					**6.21**
Planting - seed *	Sep	with above			8 kg	100%	6.18	33.12	**33.12**
Urea application	Sep	with above	40 kgN		87 kg	100%	0.47	27.40	**27.40**
Herbicide - cotogard ground spray *	Sep	with above			3.0 L	40%	12.65	10.17	**10.17**
Herbicide - dual ground spray *	Sep	with above			2.0 L	40%	17.24	9.24	**9.24**
Cultivation - inter-row	Oct	0.17	37.13	6.31					**6.31**
Insecticide - fipronil 200g/L	Nov	0.03	31.46	0.94	0.06 L	40%	300.00	4.82	**5.76**
Herbicide - shielded sprayer	Nov	0.10	35.46	3.55				0.00	**3.55**
Herbicide - glyphosate ground spray	Nov	with above			2.0 L	40%	5.42	2.91	**2.91**
Herbicide - shielded sprayer	Nov	0.10	35.46	3.55				0.00	**3.55**
Herbicide - glyphosate ground spray	Nov	with above			2.0 L	40%	5.42	2.91	**2.91**
Insecticide - BT	Dec	0.03	31.46	0.94	2.0 L	50%	22.90	15.34	**8.61**
Insecticide - amitraz EC	Dec	with above			2.0 L	50%	13.32	8.92	**8.92**
Growth Regulator - mepiquat -ground *	Jan	0.03	31.46	0.94	0.5 L	75%	28.85	7.25	**8.19**
Insecticide - emamectin	Jan	0.03	31.46	0.94	0.7 L	60%	96.00	27.01	**17.15**
Insecticide - spinosad 480g/L	Jan	0.03	31.46	0.94	0.2 L	75%	320.00	32.16	**25.06**
Insecticide - deltamethrin	Feb	aerial spray		12.50	0.7 L	100%	24.85	11.65	**24.15**
Insecticide - amitraz	Feb	with above			2.0 L	100%	13.32	17.85	**17.85**
Insecticide - chlorpyrifos	Feb	aerial spray		12.50	5.0 L	100%	9.35	31.32	**43.82**
Insecticide - ethion + zeta-cypermethrin	Feb	with above			2.2 L	100%	17.79	26.22	**26.22**
Insecticide - thiodicarb WP/WG	Mar	aerial spray		12.50	1.2 kg	100%	53.00	42.61	**55.11**
Defoliant - thidiazuron	Apr	aerial spray		12.50	0.25 L	100%	142.32	23.84	**36.34**
Defoliant - crop oil	Apr	with above			2.0 L	100%	2.48	3.32	**3.32**
Defoliant - salt defoliant-aerial *	Apr	aerial spray		12.50	2.0 L	100%	1.25	1.68	**14.18**
Contract stripper picking and module building *	Apr	contract		$150/hr	@ 0.67 hrs/ha				**109.88**
Contract Module lifting	May	contract		$50	/module @ 17 bales per module				**7.94**
Contract module cartage to gin	May	contract		$3.35	/km @	50 km from gin			**26.60**
Ginning charges	May	contract		$60	/bale				**162.00**
Consultant	May	contract							**45.00**
ACF levy and Research levy	May			$3.75	/bale				**10.13**
								TOTAL COSTS:	**$831**
								C. GROSS MARGIN $/HA:	**$485**
								Costs as a percentage of income:	**63%**

Table 11: Sensitivity table single skip



Lint Yield bales/ha	Seed Yield t/ha	$380 /bale $140/t	$405 /bale $150/t	At Gin Price **$430 /bale** **$160/t**	$460 /bale $170/t	$490 /bale $180/t	**Lint price Seed price**
1.50	0.5	(100)	(57)	(15)	35	85	
1.90	0.7	50	104	159	223	287	
2.30	0.8	185	251	316	393	470	**Gross**
2.70	**1.0**	335	412	**490**	581	672	**Margin**
3.20	1.2	514	606	698	806	914	**($/ha)**
3.70	1.3	680	786	891	1,015	1,139	
4.20	1.5	860	980	1,100	1,241	1,382	
4.70	1.7	1,040	1,174	1,309	1,467	1,625	

AGRONOMIC NOTES - SINGLE SKIP ROW

Insects: Various insecticides are available for early season pest control (eg thrips, wireworms) but not included here, since they are not always required.

Fipronil is applied for mirid control.

The selection of insecticides is highly dependent on the insect spectrum, growers should be aware this is a generic program and selection of products should be made with IPM strategies in mind. Refer to the "Integrated Pest Management Guidelines for Australian Cotton". Rotation of insecticides should be followed as per industry strategy, which changes each year due to changes in insect resistance to chemicals from season to season. For more detailed information, see the NSW Agriculture "Cotton Pest Management Guide 2001-2002".

***** Costs denoted are discounted by 33% for inclusion in the skip row system. Use of a particular brand name does NOT imply recommendation of that brand by NSW Agriculture. Always read chemical labels and follow directions, as it is your legal responsibility to do so.

Management: This budget is for a long fallow following a winter cereal crop. Skip row allows significant cost savings to be made during the growing season and at harvest, but there is a yield trade-off.

Fertiliser: Fertiliser requirements should be based on paddock records and soil tests.

Weeds: To reduce the likelihood of herbicide resistance, rotate herbicide groups and weed management techniques.

Price: Dryland cotton sometimes receives a price discount due to stable length and trash content. An average discount of $20/bale has been used in this budget.

Defoliant: The kind of defoliant used depends on the moisture status of the plant.

MACHINERY ASSUMPTIONS: Tractor: 170 KW PTO (230 HP) and 200 KW engine (265 HP) Machinery costs refer to variable costs of: fuel, oil, filters, tyres, batteries and repairs.

Table 12: Dryland cotton double skip.

INCOME:	**Lint:**	2.50	bales/ha at	$430	*/bale (at gin)..	$1,075
	Seed:	0.90	tonnes/ha at	$160	/tonne (at gin)......................................	$144
					A. TOTAL INCOME $/ha:	**$1,219**

Variable costs:

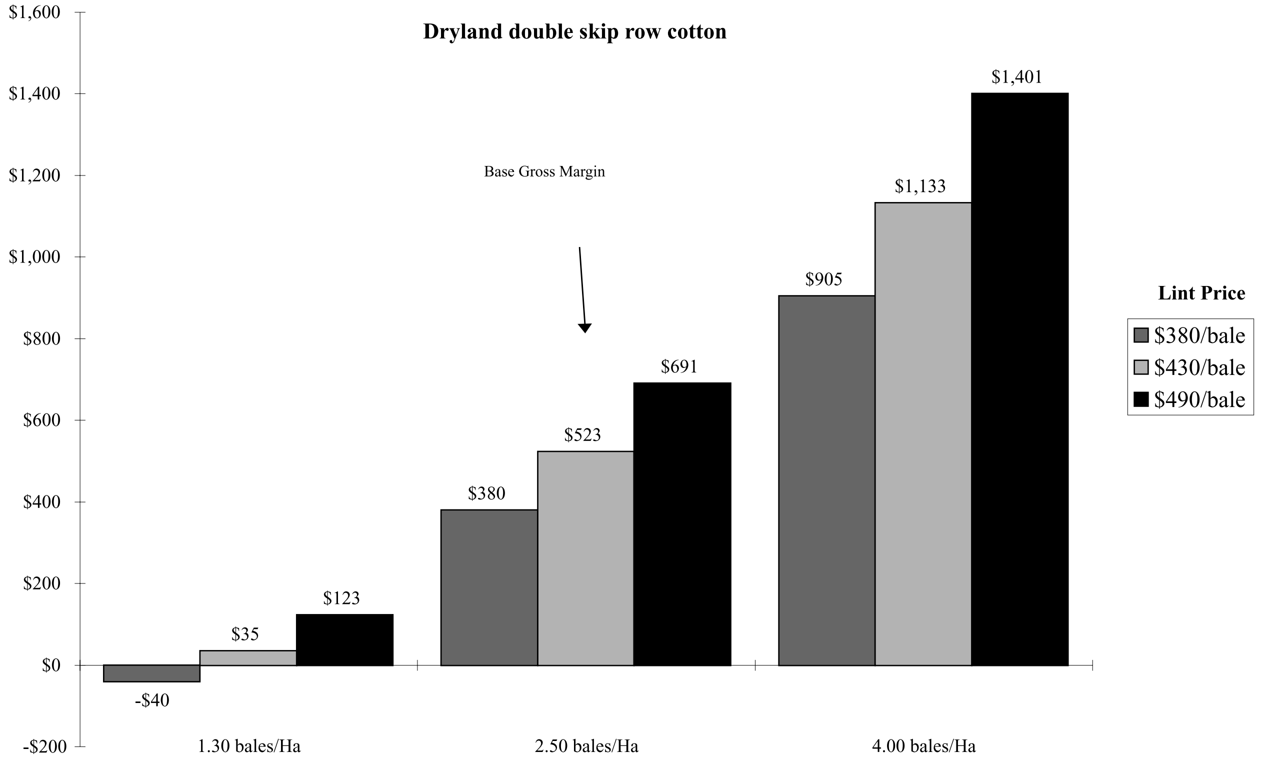
CALENDAR OF OPERATIONS:

Operation	Month	Machinery hrs /ha	Machinery Cost $/hour	Machinery Total $/ha	Inputs Rate/ha	Inputs Band Width	Inputs Cost $	Inputs Total $/ha	Total Cost $/ha
Cultivation - chisel plough	Jan	0.14	40.46	5.66					**5.66**
Cultivation - chisel plough	Apr	0.14	40.46	5.66					**5.66**
Cultivation - scarifier	Jun	0.13	37.96	4.93					**4.93**
Herbicide - glyphosate CT ground spray	Aug	0.03	31.46	0.94	0.7 L	100%	5.23	1.83	**2.77**
Wetter - non-ionic surfactant	Aug	with above			0.2 L	100%	6.43	0.64	**0.64**
Cultivation - harrow	Sep	0.13	37.96	4.93					**4.93**
Herbicide - trifluralin ground spray	Sep	with above			2.1 L	100%	7.81	8.20	**8.20**
Crop insurance	Sep							24.38	**24.38**
Planting - precision planter	Sep	0.16	38.79	6.21					**6.21**
Planting - seed *	Sep	with above			8 kg	100%	6.18	24.72	**24.72**
Urea application	Sep	with above	40 kgN		87 kg	100%	0.47	20.45	**20.45**
Herbicide - cotogard ground spray *	Sep	with above			3.0 L	40%	12.65	7.59	**7.59**
Herbicide - dual ground spray *	Sep	with above			2.0 L	40%	17.24	6.90	**6.90**
Cultivation - inter-row	Oct	0.17	37.13	6.31					**6.31**
Insecticide - fipronil 200g/L	Nov	0.03	31.46	0.94	0.06 L	40%	300.00	3.60	**4.54**
Herbicide - shielded sprayer	Nov	0.10	35.46	3.55					**3.55**
Herbicide - glyphosate ground spray	Nov	with above			2.0 L	40%	5.42	2.17	**2.17**
Herbicide - shielded sprayer	Nov	0.10	35.46	3.55					**3.55**
Herbicide - glyphosate ground spray	Nov	with above			2.0 L	40%	5.42	2.17	**2.17**
Insecticide - BT	Dec	0.03	31.46	0.94	2.0 L	50%	22.90	11.45	**6.67**
Insecticide - amitraz EC	Dec	with above			2.0 L	50%	13.32	6.66	**6.66**
Growth Regulator - mepiquat -ground *	Jan	0.03	31.46	0.94	0.5 L	75%	28.85	5.41	**6.35**
Insecticide - emamectin	Jan	0.03	31.46	0.94	0.7 L	60%	96.00	20.16	**13.04**
Insecticide - spinosad 480g/L	Jan	0.03	31.46	0.94	0.2 L	75%	320.00	24.00	**18.94**
Insecticide - deltamethrin	Feb	aerial spray		12.50	0.7 L	100%	24.85	8.70	**21.20**
Insecticide - amitraz	Feb	with above			2.0 L	100%	13.32	13.32	**13.32**
Insecticide - chlorpyrifos	Feb	aerial spray		12.50	5.0 L	100%	9.35	23.38	**35.88**
Insecticide - ethion + zeta-cypermethrin	Feb	with above			2.2 L	100%	17.79	19.57	**19.57**
Insecticide - thiodicarb WP/WG	Mar	aerial spray		12.50	1.2 kg	100%	53.00	31.80	**44.30**
Defoliant - thidiazuron	Apr	contract		12.50	0.25 L	100%	142.32	17.79	**30.29**
Defoliant - crop oil	Apr	with above			2.0 L	100%	2.48	2.48	**2.48**
Defoliant - salt defoliant-aerial *	Apr	aerial spray		12.50	2.0 L	100%	1.25	1.25	**13.75**
Contract stripper picking and module building *	Apr	contract		$150/hr @ 0.5 hrs/ha					**82.00**
Contract Module lifting	May	contract		$50	/module @ 17 bales per module				**7.35**
Contract module cartage to gin	May	contract		$3.35	/km @ 50 km from gin				**24.63**
Ginning charges	May	contract		$60	/bale				**150.00**
Consultant	May	contract							**45.00**
ACF levy and Research levy	May			$3.75	/bale				**9.38**
								TOTAL COSTS:	**$696**
								C. GROSS MARGIN $/HA:	**$523**
								Costs as a percentage of income:	**43%**

AGRONOMIC NOTES - DOUBLE SKIP ROW

Insects: Various insecticides are available for early season pest control (eg thrips, wireworms) but not included here, since they are not always required. **#** Fipronil is applied for mirid control. **##** The selection of insecticides is highly dependent on the insect spectrum, growers should be aware this is a generic program and selection of products should be made with IPM strategies in mind. Refer to the "Integrated Pest Management Guidelines for Australian Cotton". Rotation of insecticides should be followed as per industry strategy, which changes each year due to changes in insect resistance to chemicals from season to season. For more detailed information, see the NSW Agriculture "Cotton Pest Management Guide 2001-2002". * Costs denoted are discounted by 50% for inclusion in the skip row system. Use of a particular brand name does NOT imply recommendation of that brand by NSW Agriculture. Always read chemical labels and follow directions, as it is your legal responsibility to do so. **Management:** This budget is for a long fallow following a winter cereal crop. Skip row allows significant cost savings to be made during the growing season and at harvest, but there is a yield trade-off. **Fertiliser:** Fertiliser requirements should be based on paddock records and soil tests. **Weeds:** To reduce the likelihood of herbicide resistance, rotate herbicide groups and weed management techniques. **Price:** Dryland cotton sometimes receives a price discount due to stable length and trash content. An average discount of $20/bale has been used in this budget. **Defoliant:** The kind of defoliant used depends on the moisture status of the plant. **MACHINERY ASSUMPTIONS: Tractor:** 170 KW PTO (230 HP) and 200 KW engine (265 HP). Machinery costs refer to variable costs of: fuel, oil, filters, tyres, batteries and repairs.

Table 13: Sensitivity table, double skip



		At Gin Price					
Lint Yield bales/ha	**Seed Yield t/ha**	$380 /bale $140/t	$405 /bale $150/t	**$430 /bale $160/t**	$460 /bale $170/t	$490 /bale $180/t	**Lint price Seed price**
1.30	0.5	(40)	(3)	35	79	123	
1.70	0.6	95	144	192	249	306	
2.10	0.8	244	305	365	436	507	**Gross**
2.50	**0.9**	380	451	**523**	607	691	**Margin**
3.00	1.1	560	646	732	833	934	**($/ha)**
3.50	1.3	739	840	940	1,058	1,176	
4.00	1.4	905	1,019	1,133	1,267	1,401	
4.50	1.6	1,085	1,213	1,342	1,493	1,644	

Table 14: Dryland cotton (refugia for Ingard® cotton).

CALENDAR OF OPERATIONS:		Machinery			Inputs				Total
			Cost	Total		Band	Cost	Total	Cost
Operation	Month	hrs /ha	$/hour	$/ha	Rate/ha	Width	$	$/ha	**$/ha**
Cultivation - chisel plough	Jan	0.14	40.46	5.66					**5.66**
Cultivation - chisel plough	Apr	0.14	40.46	5.66					**5.66**
Cultivation - scarifier	Jun	0.17	34.46	5.86					**5.86**
Herbicide - glyphosate ground spray	Aug	0.03	31.46	0.94	0.7 L	100%	5.23	3.66	**4.60**
Wetter - non-ionic surfactant	Aug	with above			0.2 L	100%	6.43	1.29	**1.29**
Cultivation - scarifier	Sep	0.17	34.46	5.86					**5.86**
Herbicide - trifluralin ground spray	Sep	with above			2.1 L	100%	7.81	16.40	**16.40**
Planting - precision planter	Sep	0.16	38.79	6.21					**6.21**
Planting - seed	Sep	with above			10 kg	100%	6.18	61.80	**61.80**
Urea incorporation	Sep	with above	40 kgN		87 kg	100%	0.47	40.89	**40.89**
Herbicide - fluometuron+prometryn ground spray	Sep	with above			3.0 L	40%	12.65	15.18	**15.18**
Herbicide - metolachlor ground spray	Sep	with above			2.0 L	40%	17.24	13.79	**13.79**
Crop insurance	Sep							51.20	**51.20**
Cultivation - inter-row	Oct	0.17	37.13	6.31					**6.31**
Insecticide - fipronil 200g/L	Nov	0.03	31.46	0.94	0.06 L	40%	300.00	7.20	**8.14**
Herbicide - shielded sprayer	Nov	0.10	35.46	3.55					**3.55**
Herbicide - glyphosate ground spray	Nov	with above			2.0 L	40%	5.23	4.18	**4.18**
Insecticide - amitraz EC	Dec	0.03	31.46	0.94	2.0 L	50%	13.32	13.32	**14.26**
Herbicide - shielded sprayer	Dec	0.10	35.46	3.55					**3.55**
Herbicide - glyphosate ground spray	Dec	with above			2.0 L	40%	5.23	4.18	**4.18**
Growth Regulator - mepiquat -ground	Jan	0.03	31.46	0.94	0.5 L	75%	28.85	10.82	**11.76**
Insecticide - emamectin	Jan	0.03	31.46	0.94	0.7 L	60%	96.00	40.32	**41.26**
Insecticide - spinosad 480g/L	Jan	0.03	31.46	0.94	0.2 L	75%	320.00	48.00	**48.94**
Insecticide - deltamethrin	Feb	aerial spray		12.50	0.7 L	100%	24.85	17.40	**29.90**
Insecticide - amitraz	Feb	with above			2.0 L	100%	13.32	26.64	**26.64**
Insecticide - chlorpyrifos	Feb	aerial spray		12.50	5.0 L	100%	9.35	46.75	**59.25**
Insecticide - ethion + zeta-cypermethrin	Feb	with above			2.2 L	100%	17.79	39.14	**39.14**
Insecticide - thiodicarb WP/WG	Mar	aerial spray		12.50	1.2 kg	100%	53.00	63.60	**76.10**
Defoliant - thidiazuron	Apr	aerial spray		12.50	0.25 L	100%	142.32	35.58	**48.08**
Defoliant - crop oil	Apr	with above			2.0 L	100%	2.48	4.96	**4.96**
Defoliant - salt defoliant-aerial	Apr	aerial spray		12.50	2.0 L	100%	1.25	2.50	**15.00**
Contract Spindle picking									
and module building	May	contract		$280/hr @ 1.0 hrs/ha					**280.00**
Contract Module lifting	May	contract		$50	/module @	17 bales per module			**8.82**
Contract module cartage to gin	May	contract		$3.35	/km @	50 km	from gin		**29.56**
Ginning charges	May	contract		$60	/bale				**180.00**
Consultant	May	contract							**45.00**
ACF levy and Research levy	May			$3.75	/bale				**11.25**
								TOTAL COSTS:	**1,234**
								TOTAL COSTS for 0.5 hectare:	**617**

AGRONOMIC NOTES - REFUGIA FOR INGARD

For further details see the NSW Agriculture "Cotton Pest Management Guide 2001-2002".

INSECTS: - Since this is a refuge crop for preventative resistance management in growing Ingard® cotton, no foliar Bt sprays are used.

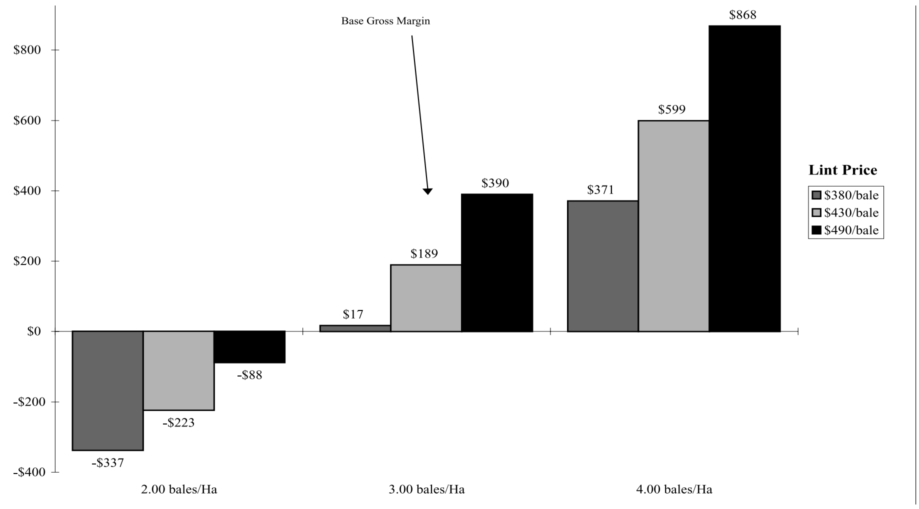
Always read chemical labels and follow directions, as it is your legal responsibility to do so. Use of a particular brand name does NOT imply recommendation of that brand by NSW Agriculture.

MACHINERY ASSUMPTIONS: Tractor: 170 KW PTO (230 HP) and 200 KW engine (265 HP) Machinery costs refer to variable costs of: fuel, oil, filters, tyres, batteries and repairs. You may need to add overhead costs as well, please refer to the Tractor and Implement Costs Guide

Table 15: Dryland cotton (Ingard®).

CALENDAR OF OPERATIONS:		Machinery			Inputs				Total
			Cost	Total		Band	Cost	Total	Cost
Operation	Month	hrs /ha	$/hour	$/ha	Rate/ha	Width	$	$/ha	**$/ha**
Cultivation - chisel plough	Jan	0.14	40.46	5.66					**5.66**
Cultivation - chisel plough	Apr	0.14	40.46	5.66					**5.66**
Cultivation - scarifier	Jun	0.17	34.46	5.86					**5.86**
Herbicide - glyphosate ground spray	Aug	0.03	31.46	0.94	0.7 L	100%	5.23	3.66	**4.60**
Wetter - non-ionic surfactant	Aug	with above			0.2 L	100%	6.43	1.29	**1.29**
Cultivation - scarifier	Sep	0.17	34.46	5.86					**5.86**
Herbicide - trifluralin ground spray	Sep	with above			2.1 L	100%	7.81		**0.00**
Crop insurance	Oct	Premium depends on various factors						51.20	**51.20**
Planting - precision planter	Oct	0.16	38.79	6.21		100%			**6.21**
Planting - seed	Oct	with above			12 kg	100%	6.18	74.16	**74.16**
Urea incorporation	Sep	with above	40 kgN		87 kg	100%	0.47	40.89	**40.89**
Herbicide - prometryn 500 SC	Oct	with above			3.5 L	40%	12.65	17.71	**17.71**
Cultivation - interrow	Nov	0.17	37.13	6.31		100%			**6.31**
Cultivation - interrow	Dec	0.17	37.13	6.31		100%			**6.31**
Cultivation - interrow	Jan	0.17	37.13	6.31		100%			**6.31**
Insecticide - spinosad 480g/L	Jan	0.03	31.46	0.94	0.2 L	60%	320.00	38.40	**39.34**
Ingard® Licence fee **	Jan							155.00	**155.00**
Insecticide - bifenthrin	Feb	aerial spray		12.50	0.8 L	100%	62.46	49.97	**62.47**
Insecticide - amitraz	Feb	with above			2.0 L	100%	13.32	26.64	**26.64**
Insecticide - profenefos	Feb	aerial spray			2.0 L	100%	12.88	25.76	**25.76**
Insecticide - thiodicarb WP/WG	Mar	aerial spray			1.2 kg	100%	53.00	63.60	**63.60**
Defoliant - thidiazuron (eg Dropp Ultra®)	Mar	aerial spray		12.50	0.25 L	100%	142.32	35.58	**48.08**
Defoliant - crop oil	Mar	with above			2.0 L	100%	2.48	4.96	**4.96**
Defoliant- ethephon (eg Prep®)	Mar	with above			1.5 L	100%	23.83	35.75	**35.75**
Defoliant- ethephon (eg Prep®)	Mar	aerial spray		12.50	2.0 L	100%	23.83	47.66	**60.16**
Contract picking & module building	May	contract		$280/hr	@ 1.00	hours/ha			**280.00**
Contract Module lifting	May	contract		$50.00	/module @ 17 bales per module				**8.82**
Contract module cartage to gin	May	contract		$3.35	/km @	50 km	from gin		**29.56**
Ginning charges	May	contract		$60.00	/bale				**180.00**
ACF levy and Research levy	May	contract		$3.75	/bale				**11.25**
Consultant	May	contract							**45.00**
								TOTAL COSTS:	**1,314**
								TOTAL COSTS for 0.5 hectare of Ingard®:	**657**

Table 16: Sensitivity table, dryland cotton (Ingard®).



Lint bales/ha	Seed t/ha	$380 /bale $140/t	$405 /bale $150/t	**$430 /bale $160/t**	$460 /bale $170/t	$490 /bale $180/t	**Lint price Seed price**
1.50	0.54	(514)	(471)	(429)	(378)	(328)	
2.00	0.72	(337)	(280)	(223)	(156)	(88)	
2.50	0.90	(160)	(88)	(17)	67	151	**Gross**
3.00	**1.08**	17	103	**189**	290	390	**Margin**
3.50	1.26	194	295	395	512	630	**($/ha)**
4.00	1.44	371	485	599	734	868	
4.50	1.62	548	677	805	956	1,108	

AGRONOMIC NOTES - INGARD SOLID PLANT

MANAGEMENT:- # Fipronil is applied for mirid control.

The selection of insecticides is highly dependent on the insect spectrum, growers should be aware this is a generic program and selection of products should be made with IPM strategies in mind. Refer to the "Integrated Pest Management Guidelines for Australian Cotton". Each grower is required to grow a refuge crop as part of preventative resistance management. Since the refuge crop is an integrated part of growing Ingard® cotton, refuge crop costs and income have been included as part of the gross margin budget. Refuge options required for each 100ha of dryland Ingard® are a minimum of - 10ha cotton untreated for heliothis, or -100ha cotton conventionally managed for heliothis and other pests. For the purposes of this example, we have used cotton conventionally managed for heliothis and other pests with no Bt sprays. Since these budgets are on a per hectare basis, we have used half a hectare of conventionally managed cotton with no Bt sprays for the refuge crop, the full budget for which is shown in the preceding pages, and half a hectare of Ingard® cotton. No foliar Bt sprays are to be used on the refuge crop. Refuge crops should be - planted and managed so the refuge is attractive to heliothis during the growing period of Ingard®, - planted within the farm unit growing Ingard®, prefereably on one side or adjacent to the Ingard® crop, with a seperation of no more than 2km from the Ingard® crop. For further details see the NSW Agriculture "Cotton Pest Management Guide 2001-2002".

HERBICIDES: Fallow herbicides have been substituted for cultivation during the winter to avoid soil compaction. To reduce the likelihood of herbicide resistance, rotate herbicide groups and weed management techniques. Use of a particular brand name does NOT imply recommendation of that brand by NSW Agriculture. Always read chemical labels and follow directions, as it is your legal responsibility to do so.

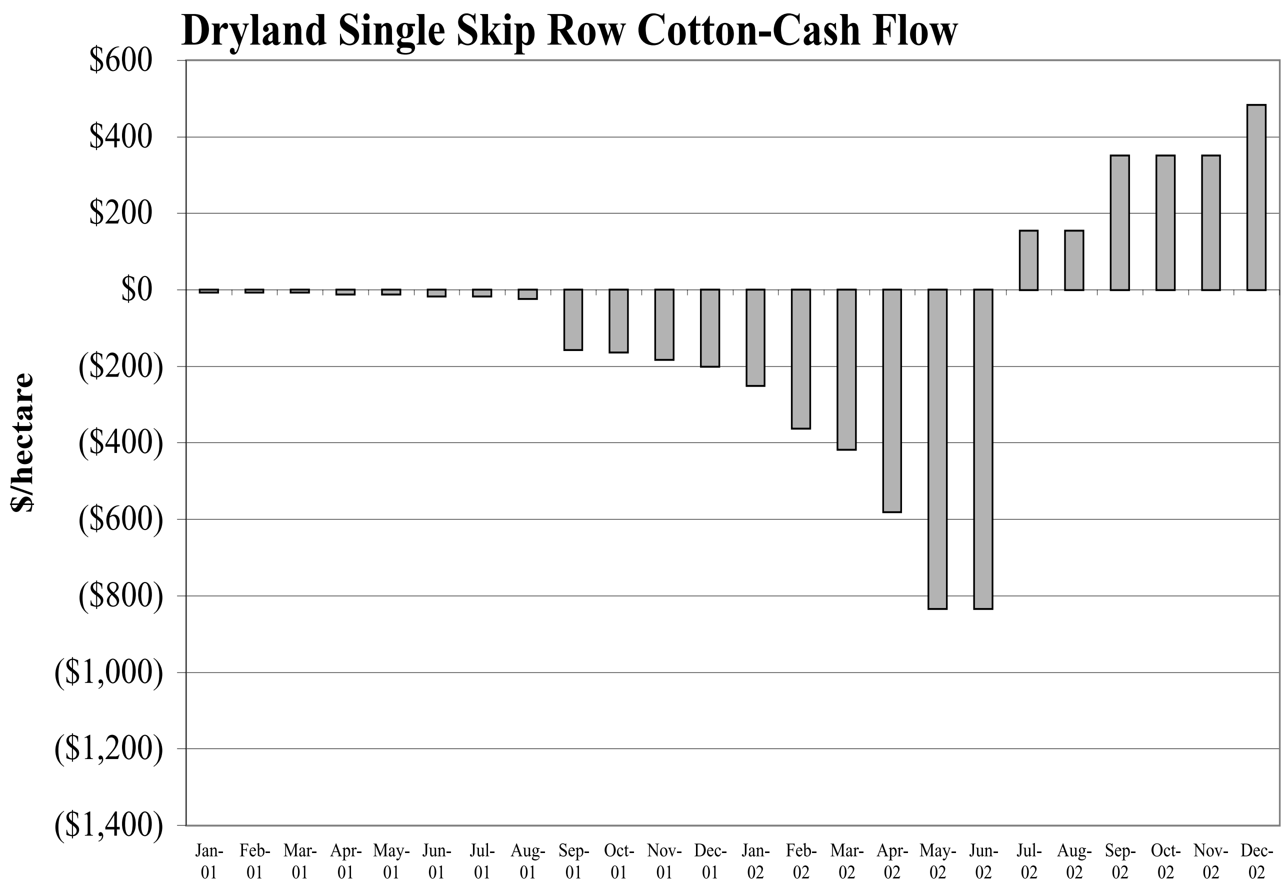
LICENCE FEE: ** The invoice licence fee is $185/ha, but a reduction of up to $30/ha is possible if audit requirements are followed. A $10/ha credit is allowed for satisfactory achievement of the first audit and second audits, with $10/ha payment to the grower on completion of the 3rd audit (August). This budget assumes audit requirements are met.

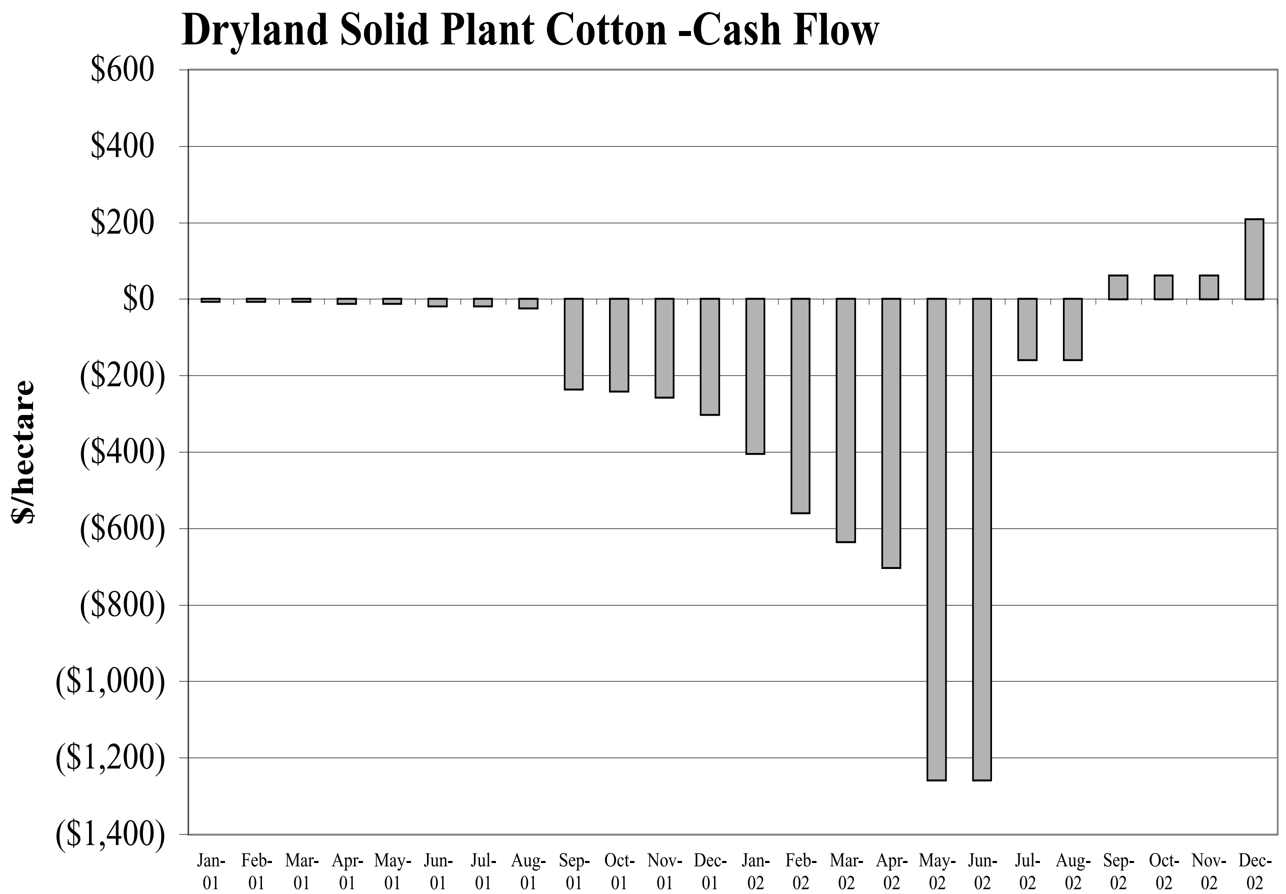
DEFOLIANT: Good conditions are required to get the best performance. The kind of defoliant used depends on the moisture status of the plant.

LABOUR REQUIREMENTS: Labour is not costed in this budget. If labour costs $14.00/hr, total labour cost would be $23.10, reducing the gross margin to $165 /ha. This still does not include labour required for extra bug checking.

MACHINERY ASSUMPTIONS: Tractor: 170KW PTO (230 HP) and 200KW engine (265HP) Machinery costs refer to variable costs of: fuel, oil, filters, tyres, batteries and repairs. You may need to add overhead costs as well, please refer to the Tractor and Implement Costs Guide.

Figure 10: Dryland cotton cashflow.





NSW Agriculture **FARM ENTERPRISE BUDGET**

Dryland Cotton – Ingard®

1.GROSS MARGIN BUDGET: INCOME:				Sample Budget $/ha	Your Budget $/ha
Ingard®					
Lint -	3.00 bales/ha at	$430	/bale (at gin).........................	$1,290.00	
Seed -	1.08 tonnes/ha at	$160	/tonne (at gin).......................	$172.80	
			Income for 0.5 hectare of Ingard®	$731.40	
Refuge: Conventionally managed cotton with no Bt sprays					
Lint -	3.00 bales/ha at	$430	/bale (at gin).........................	$1,290.00	
Seed -	1.08 tonnes/ha at	$160	/tonne (at gin).......................	$172.80	
			Income for 0.5 hectare of refuge crop:	$731.40	
			A. TOTAL INCOME $/ha:	**$1,462.80**	

VARIABLE COSTS: see opposite page for details	Ingard® 0.5 ha	Refuge 0.5 ha	Your budget Ingard® 0.5 ha	Your budget Refuge 0.5 ha
Cultivation..	$20.99	$21.57		
Sowing...	$40.19	$34.01		
Crop insurance...	$25.60	$25.60		
Fertilizer & application...	$20.45	$20.45		
Herbicide & application..	$86.28	$66.37		
Insecticide & application...	$108.91	$171.82		
Contract harvesting..	$144.41	$144.41		
Cartage to gin..	$14.78	$14.78		
Ginning charges..	$90.00	$90.00		
ACF and Research Levy...	$5.63	$5.63		
Ingard® licence fee……………………………………..	$77.50	na		
Other (eg consultant)..	$22.50	$22.50		
Sub-totals…………………………………	**$657.24**	**$617.14**		
B. TOTAL VARIABLE COSTS $/ha:		**$1,274.38**		
C. GROSS MARGIN (A-B) $/ha:		**$188.42**		

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 broadacre 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 - 400 ha 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

Work rates

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

KEY POINTS:

- **Minimise costs by modifying and adapting existing equipment**
- **Check availibility of contractors**
- **Match work rates to the area planted**

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 symptons 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 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 dryland 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 airseeders 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).

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 seeding rate.
- Replacing older convoluted hoses with modern smooth bore hoses.
- Keeping air velocities up in the hoses leading to the distribution heads.
- Using two distributor 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 duckfoot 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 presswheel. 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 dryland 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.

Water Injection

While water injection is used successfully by a number of growers it is not a substitute for insufficient moisture. Seed must still be placed into soil moisture with the added water used to reduce the dry back effect. The primary role of water injection is a carrier for starter fertiliser such as MAP, zinc application and for seedling protection with insecticides such as Lorsban. Water injection allows the seed to imbibe moisture at a faster rate, which increases the rate and evenness of establishment. While plant vigour is often increased, the total percentage of established plants may not. Water is generally directed into the seed trench about 5cm behind the seed tube. Water rates vary from 500 to 2000L/ha with 1000L/ha a common rate. Planting efficiency, which equates to area planted per day, is substantially reduced by water injection. Reductions of between 20% to 40% in area planted per day are common. If water is the only additive in this operation, both the economic and agronomic benefit of water injection must be questioned.

Seed Soaking

Soaking seed can speed up germination by 1 to 2 days. Under hot, dry conditions conducive to rapid drying within the seedbed, this may provide a better overall establishment. Generally, seed is soaked for 2.5 to 3 hours, dried overnight, and then planted without delay next day, to avoid emergence of the radicle (primary root) prior to planting. Quantities sufficient for half a day's planting are generally done at one time. If planting is delayed, seed can be salvaged by complete drying on a tarp.

The actual process involves placing seed into hessian wheat bags or perforated drums, and immersing in a tank of water, remembering to allow room for expansion. The swollen seed, generally about 30% larger, requires planter plates to be changed for planting. Another drawback is the likely loss of seed treatments, increasing the risk of seedling diseases under cool seedbed conditions.

INTER-ROW CULTIVATING

In-crop weed control is most economically accomplished by cultivation. Any 3pt linkage bar can be set up with either cultivating tynes or knives. Depth control wheels are recommended especially with heavier bars. The width of cultivating bars should be matched to some multiple of the planter to overcome the problem of guess rows. Tracking devices are also being used to overcome uneven row spacings.

FALLOW MANAGEMENT & CROP ROTATION

By John Marshall, CSD

KEY POINTS:

- **Modern fallow management practices have a strong impact on improved long term average yields**
- **Rotation crops impact both positively and negatively on the following cotton crop. Consider the choices carefully.**

Wherever dryland cotton is grown, the amount of stored soil moisture at planting time is the critical agronomic factor influencing the decision to plant. In those areas with higher summer rainfall and / or soils with better water holding capacity e.g. Central Darling Downs, Liverpool Plains, 60cm of wet soil is considered to be the minimum requirement. For most dryland cotton growing areas, 90cm of wet soil is the minimum required. This would translate to 140-180mm stored plant-available water, depending on soil type.

TYPES OF FALLOWS

Long fallow

One practice has been to grow dryland cotton every second summer, without any rotation crops, giving a fallow of approximately 18 months duration.

While optimising the potential for soil moisture storage, this fallow system has a number of negative aspects. Mycorrhizal problems frequently occur because of the absence of growing plants for such an extended period. Ground cover is almost negligible, contributing to water run off and erosion problems. This system has a very low fallow efficiency, a measure of crop produced per mm of rainfall during fallow. Maximising fallow efficiency is a major consideration in dryland crop production.

Standard fallow

Dryland cotton is commonly planted after a 10-11 month fallow from a winter cereal. The following are important considerations for the practice:

• it allows for the retention of high levels of cereal stubble on the soil surface until planting, and even beyond, to maximise rainfall entry and storage in the soil

• standing stubble reduces run off and soil movement on both sloping and floodplain areas

• retention of cereal stubble on the soil surface after planting protects vulnerable young seedlings from sandblasting

• timely control of weeds and volunteer cereals will preserve soil moisture

• delaying cultivation in the early part of the fallow will help retain post harvest soil cracking patterns which aids soil profile wetting from the bottom up. Less soil disturbance slows moisture loss from the surface layers and reduces weed germination.

Short fallow

Quite satisfactory yields have been obtained from cotton grown after a short (6 months) fallow from sorghum, millet or mung beans in years of above average autumn or winter rainfall. Management practices such as pre-harvest crop or post-harvest stubble spraying of sorghum with glyphosate, will help to maximise the potential amount of soil moisture stored. Early planting the previous spring, a timely dry harvest and minimal soil and stubble disturbance post-harvest will improve the chances of the system being successful.

If the country has to be cultivated, operations should be light and as few as possible. Heavy operations which create a rough, open surface will require an excessive number of subsequent passes to fine down, with potential compaction problems in wet winters.

SEEDBED PREPARATION

Obtaining a satisfactory plant stand can be a challenge in dryland cropping. Two major requirements for cotton planting are surface and deeper stored moisture to be well joined up and a suitable seedbed tilth. Some growers furrow out fields late in the fallow in the hope of creating a more favourable planting microenvironment in the furrow if planting rain is marginal. Some heavier clay soils may require cultivation(s) late in the fallow to obtain a desirable tilth. Adding nitrogen fertiliser in bands in tramlined fields helps minimise soil disturbance in no-till fields. Care needs to be taken in cultivated land, not to 'shallow up' the seedbed too early. Every grower needs to develop a system which suits his particular soil type and planting equipment.

Managing soil compaction

Cotton growth can be badly affected by compacted zones in soil. Tramlining the paddock in its planting configuration early in the fallow will reduce the chance of this occurring. Avoid working if the soil is too wet and use the minimum tyre pressures on all wheeled equipment. If wheel tracks have come through from the previous harvest, nurture them early. Fill and level track marks by light cultivation with either light offsets or a cultivator. During the planting operation, avoid planting into wheel tracks.

If soil compaction problems are suspected, take a shovel and physically check the soil profile. If dense layers are found, cultivation at a depth just below the damaged areas is the most effective means of amelioration. Subsequently, management strategies should be adopted to minimise re-occurrence.

Weed control

Weed control is important both in the fallow and during the crop. Many of the residual herbicides used in grain cropping systems are damaging to cotton. These include the sulfonyl ureas and atrazine.

The residual life of many of these herbicides (in the soil) is unpredictable, being dependent on climatic conditions and soil pH. As a general rule, if it is likely that cotton will be the following crop, use of these groups of chemicals should be minimised during the previous crop, and most importantly during the fallow.

Trifluralin is one of the cheapest and most effective herbicides for use in cotton. In areas where the planting window is narrow, its application pre-plant can rule out most other crops as a substitute should cotton not be planted, or be hailed out early. Its requirements for incorporation into a relatively stubble free seedbed also creates some problems in minimum till situations.

Diuron is another residual herbicide that can restrict later planting choices if used late in the fallow. The practice of banding herbicides requiring minimal incorporation, at planting, is an alternate. However, in dry years, these are often not activated very effectively, resulting in poor weed control.

A clean weed free start is essential for a cotton crop as early weed competition can seriously impact on yield. The application of a knockdown herbicide(s) immediately pre-plant or post-plant, pre-emergent helps ensure such a start. Weeds at this stage are normally young, fresh and very susceptible to relatively low rates of herbicide. The availability of Roundup Ready® cotton allowing over the top application of Roundup up to but not including the 5th true leaf greatly extends the window for this control.

When selecting knockdown herbicides for pre-plant application, note that 2,4-D products have a 10-21 day plant-back interval with cotton. **Table 20** provides information on plant back for cotton from fallow herbicides while **Table 36** gives plant back periods for other crops after herbicide use in cotton. **Table 33** gives herbicide selection for various weeds. NSW Agriculture's *Cotton Pest Management Guide* contains current herbicide registrations.

Nitrogen application

In dryland cotton, nitrogen is normally incorporated in a pre-plant application. This application should occur late in the fallow to reduce the likelihood of denitrification, yet early enough so that any concentrated band of fertiliser does not reduce germination. The use of 'cold-flo' anhydrous ammonia or granular products reduces the need for deep application and accompanying seedbed damage.

In tramlined no-till fields, application of fertiliser in bands can help maintain standing stubble cover over the majority of the field beyond planting. Applying the bulk of the crop's N requirements as an in-crop sidedressing is not recommended. It is likely to become tied up in dry soil, and only become available later in the growing season, causing potential regrowth problems.

Nitrogen Rate

The amount of nitrogen fertiliser required to be added will depend on the amount of stored water i.e. the crop potential and the soil N level. High yielding environments will need more available N. A cotton crop removes about 12kg/ha of N per bale and requires about double this amount to grow the crop. A field expected to produce 4 bales/ha would need at least 96kg of available N in the profile. The amount of nitrogen in the profile is measured well before planting, and a decision made if N needs to be topped up.

Strip trials and experience can also assist in determining the fertiliser requirement. In general, fertiliser should be applied to a level that will produce a better than average crop as the opportunity cost of having insufficient N is considerable. However excessive amounts of N can create management problems with insect control, defoliation and regrowth difficulties.

CROP ROTATION

Factors that need to be considered when looking at developing rotations involving dryland cotton include:

- fallow soil moisture accumulation
- provision for influencing Heliothis population dynamics
- potential for disease build-up
- influence on VAM (Vesicular Arbuscular Mycorrhizae
- influence on fallow nitrogen
- residual herbicides

Only in years of above average autumn / winter rainfall would back-to-back cotton be a consideration in a dryland situation. **Table 19** outlines a number of possible rotational options currently being used in the dryland cotton areas.

Rotation 1 can experience VAM problems, and generally has lower water use efficiency due to more runoff, during a longer fallow. N movement to depth and denitrification are more likely to occur with this system.

Rotations 2 and 3 are commonly practiced rotations in dryland cotton areas. They maximise the chances of high levels of stored soil moisture at planting. Use of reduced or no tillage practices will help maintain standing stubble to lessen soil erosion and runoff. Low VAM levels in the soil with consequent nutrient unavailability is generally not a problem, especially where sorghum is grown. The winter cereal component is grown primarily for cover considerations.

Rotations 4 and 5 are dependent on good rainfall occurring during Autumn, as the cotton finishes. Rotations involving winter cereals provide better surface cover during the following summer fallow than winter legumes, usually resulting in better soil moisture storage and erosion control. While *Rotation 4* has the potential to reduce artificial nitrogen inputs, the winter legume option can potentially contribute to later season Heliothis control problems. Similarly sorghum in rotation in adjacent strips can reduce Heliothis control options due to drift concerns. Late sorghum can however, act as a sink for Heliothis, and prove an excellent tool too assist in their control.

Rotation 6 increases the frequency of cropping, and the level of ground cover. To maximise the chance of re-wetting the soil profile before cotton, the alternative summer crops must be planted as early as possible in spring. A high level of N management is necessary under this system.

Table 17 outlines the yield and return from a dryland cropping system trial conducted at Warra since 1993. The trial includes some of the rotations outlined in **Table 19**. The results to date indicate that judicious choice of rotational crops in dryland cotton systems can provide major soil sustainability benefits without detriment to gross return.

Figure 11: Aerial view of the dryland farming systems trial at Warra in Queensland (see Table 17)

Table 17: Summary – Seven year gross margins.

Years		Rotation 1 Cotton / cotton	Rotation 2 Cotton / sorghum	Rotation 3 Cotton / dc W.cereal	Rotation 4 Cotton / W.legume	Rotation 5 Cotton / W.cereal
1993/94	Crop	Fallow	Sorghum	Barley	Barley	Fallow
	Yield		2.1 t / ha	0.22 t / ha	0.22 t / ha	
	Price		$164	$155	$155	
	Income		$344	$34	$34	
	Var.Costs		$92	$52	$52	
	Gross Margin	$0	$252	($18)	($18)	$0
1994/95	Crop	Cotton	Cotton	Cotton	Chickpea	Wheat
	Yield	3.73 b / ha	3.05 b / ha	4.05 b / ha	0.66 t / ha	1.43 t / ha
	Price	$529	$529	$529	$320	$142
	Income	$1,972	$1,612	$2,141	$211	$203
	Var.Costs	$913	$837	$815	$96	$94
	Gross Margin	$1,059	$775	$1,325	$115	$109
1995/96	Crop	Fallow	Sorghum	Wheat	Cotton	Cotton
	Yield		5.77 t / ha	0.42 t / ha	4.45 b / ha	4.50 b / ha
	Price		$160	$242	$510	$510
	Income		$923	$102	$2,244	$2,295
	Var.Costs		$178	$68	$889	$927
	Gross Margin	$0	$745	$37	$1,355	$1,368
1996/97	Crop	Cotton	Cotton	Cotton	Wheat	Wheat
	Yield	3.35 b / ha	3.21 b / ha	3.80 b / ha	2.7 t / ha	2.70 t / ha
	Price	$460	$460	$460	$143	$143
	Income	1541	1476.6	$1,743	$386	$386
	Var.Costs	$782	$793	$871	$65	$65
	Gross Margin	$759	$684	$873	$321	$321
1997/98	Crop	Fallow	Sorghum	Wheat	Chickpea	Cotton
	Yield		3.05 t / ha	3.05 t / ha	2.57 t / ha	2.70 b / ha
	Price		$130	$130	$300	$450
	Income	$0	$397	$397	$771	$1,215
	Var.Costs	($63)	$142	$117	$166	$854
	Gross Margin	($63)	$255	$279	$605	$361
1998/99	Crop	Cotton	Cotton	Cotton	Cotton	Wheat
	Yield	3.8 b / ha	2.92 b / ha	4.41 b / ha	3.04 b / ha	3.79 t / ha
	Price	$480	$480	$480	$480	$153
	Income	$1,824	$1,402	$2,117	$1,459	$580
	Var.Costs	$1,005	$993	$1,018	$1,008	$107
	Gross Margin	$819	$409	$1,098	$451	$473
1999/00	Crop	Fallow	Sorghum	Wheat	Chickpea	Cotton
	Yield		5.78 t / ha	1.99 t / ha	1.03 t / ha	2.9 b / ha
	Price		$115	$180	$370	$450
	Income	$0	$665	$358	$381	$1305
	Var. Costs	($40)	$201	$155	$183	$792
	Gross Margin	($40)	$464	$203	$198	$513
7Yr Rotation Gross Margin		**$2,534**	**$3,584**	**$3,797**	**$3,027**	**$3,145**

Table 18: Possible rotational programs for strip cropped areas.

Year	1997	97/98	98	98/99	99	99/2000	2000	2000/01	2001	2001/02	2002
Season	W	S	W	S	W	S	W	S	W	S	W
Strip No											
1	Wh-dc	Wh-st	Wh-st	Cot	Cot-st	S-late	S-st	S-st	S-st	Cot	
2	S-st	S-st	S-st	Cot	Wh-dc	Wh-st	Wh-st	Cot	Cot-st	S-late	
3	Cot-st	S-late	S-st	S-st	S-st	Cot	Wh-dc	Wh-st	Wh-st	Cot	
4	Wh-st	Cot	Cot-st	S-late	S-st	S-st	S-st	Cot	Wh-dc	Wh-st	Repeat
5	S-st	Cot	Wh-dc	Wh-st	Wh-st	Cot	Cot-st	S-late	S-st	S-st	1997
6	Wh-dc	Wh-st	Wh-st	Cot	Cot-st	S-late	S-st	S-st	S-st	Cot	'W'
7	S-st	S-st	S-st	Cot	Wh-dc	Wh-st	Wh-st	Cot	Cot-st	S-late	
8	Cot-st	S-late	S-st	S-st	S-st	Cot	Wh-dc	Wh-st	Wh-st	Cot	
9	Wh-st	Cot	Cot-st	S-late	S-st	S-st	S-st	Cot	Wh-dc	Wh-st	
10	S-st	Cot	Wh-dc	Wh-st	Wh-st	Cot	Cot-st	S-late	S-st	S-st	
11	Repeat Strip No 1										

Wh-dc = Wheat Double cropped
Cot = Cotton
Wh-st = Wheat Stubble
Cot-st = Cotton Stubble
S-late = Late Sorghum
S-st = Sorghum Stubble

EROSION CONTROL IN DRYLAND COTTON

Floodplain Areas

A large proportion of Australia's dryland cotton is grown on flood plains, where erosion from overland flood flow is a serious potential threat at any time of the year. Strip cropping is a tried and proven method of controlling erosion and spreading flow in these area. The basic principle is to 'always have one foot on the ground' i.e. at any time of the year, to have standing well anchored stubble or well established crop in at least 1/3 of strips, lying across the direction of flood flow. Land levelling along fence lines and in gullied areas will improve the evenness of floodwater spread through the strips.

The stubble management practices applied within the stripcropping system are the core of its success. Because of the low level of stubble remaining and the length of fallow often associated with cotton, special challenges occur in systems involving dryland cotton. Stubble provided by other crops in the system has to last a considerable time, and remain well anchored. Sorghum and canary stubbles are the most effective in this regard. There is no doubt, that systems involving only cotton in long fallow, without other rotational crops are non sustainable. **Table 18** outlines a stripcropping program which addresses most agronomic and soil conservation requirement of a sustainable cotton production system.

Sloping Lands

On sloping land, cotton presents special challenges from a soil conservation perspective. Contour banks and contour cultivation have been the traditional way to reduce soil erosion. However, without the support of ground cover, banks are little more than silt traps.

Dryland cotton grown in a skip row configuration means that a low level of ground cover is present during the summer. If frequent inter row cultivation is carried out, this further increases the likelihood of soil erosion. Planting the crop into standing wheat or sorghum stubble, and using shielded sprayers for weed control throughout the life of the crop has the potential to greatly reduce soil erosion on sloping fields.

Research has been conducted to investigate a system where cotton is grown on beds running up and down slopes in fields tramlined to provide traffic control. Erosion can be minimised provided runoff is confined to its own bed furrow, and does not accumulate in depressions as it moves downslope. Obviously, intensive stubble management practices on the beds to reduce run off volume and peak flow rates is the key to the system being successful.

Pupae Control Conflict

One aspect of cotton production which potentially causes conflict with soil conservation practices in cotton rotations is the need for full soil disturbance to 10cm depth soon after cotton picking for control of potential overwintering pupae in the soil. Researchers, extension officers and farmers are developing practices which satisfy both requirements. These include:

- use of modelling to identify likely level of diapausing pupae
- more detailed field sampling for pupae
- late season inter row cultivation
- specialised planting equipment to give 10cm deep full disturbance
- post picking aggressive inter row cultivation in standing cotton stubble.

Table 19: Possible rotational options for dryland cotton

S	W	S	W	S	W	S	W	S	Soil H20	Surface Cover	Heliothis	Disease	VAM	Nitrogen
1.Cotton	Fallow	Fallow	Fallow	Cotton	Fallow	Fallow	Fallow	Cotton	++	--	++	++	--	+
2.Cotton	Fallow	Fallow	Winter Cereal	Fallow	Fallow	Cotton	Fallow	Fallow	++	+	++	++	+	+
3.Cotton	Fallow	Sorghum late	Fallow	Fallow	Fallow	Cotton	Fallow	Sorghum late	++	+	-	++	++	+
4.Cotton	Winter. Cereal opp	Fallow	Winter Legume	Fallow	Fallow	Cotton	Winter . Cereal opp	Fallow	+	-	-	+	++	+
5.Cotton	Winter . Cereal opp	Fallow	Fallow	Cotton	Winter Cereal . opp	Fallow	Fallow	Cotton	++	+	++	++	+	+
6.Cotton	Fallow	Sorghum Early	Fallow	Cotton	Fallow	Sorghum Early	Fallow	Cotton	-	++	-	++	++	-

Table 20: A guide to Plant–Back periods. (Please refer to current product labels).

CHEMICAL	PRODUCT	ACTIVE CONSTITUENT	APP. RATE PER HECTARE	PLANT BACK PERIOD	COMMENTS
sulfonylureas	GLEAN SIEGE	750g chlorsulfuron/kg	15-20g	18 months with a minimum of 700mm rainfall 24 months with a minimum of 700mm rainfall Glean is not recommended where soil pH is above 8.5	where soil pH is 6.6-7.5 where soil pH is 7.6-8.5 where soil pH is above 8.5
	ALLY	600g metsulfuron/kg	5-7g	15 months with a minimum of 700mm rainfall 18 months with a minimum of 700mm rainfall 18 months and then a further 700mm rainfall	where soil pH is 5.6-8.0 where soil pH is 8.1-8.5 where soil pH is above 8.6
	HARMONY M	682g thifensulfuron + 68g metsulfuron/kg	40g	15 months with a minimum of 700mm rainfall 18 months with a minimum of 700mm rainfall 18 months and then a further 700mm rainfall	where soil pH is 5.6-8.0 where soil pH is 8.1-8.5 where soil pH is above 8.6
	LOGRAN	714gt triasulfuron/kg	30-35g	12 months 22 months 24 months	where soil pH is up to 6.5 where soil pH is 6.5-7.5 where soil pH is above 7.6
	AMBER POST	20g triasulfuron + 600g terbutryn/Kg	250-500g	14 months	
2,4-D	2,4-D AMINE	500g 2,4-D amine/L	up to 0.7L 0.7-1.4L above 1.4L	10 days after at least 15mm rainfall 14 days after at least 15mm rainfall 21 days after at least 15 mm rainfall	Breakdown of 2,4-D is dependent upon microbial action under warm, moist conditions. Nominated plant back periods only commence after there has been in excess of 15mm rainfall. Extreme caution needs to be exercised under very dry conditions
	2,4-D ESTER	800g 2,4-D ester/L	up to 0.35L 0.35-0.7L 0.7-1.1L	10 days after at least 15mm rainfall 14 days after at least 15mm rainfall 21 days after at least 15 mm rainfall	
	TILLMASTER	180g 2,4-D amine + 90g glyphosate/L	up to 2.0L 2.0L–4.0L 4.0L–6.0L	10 days after at least 15mm rainfall 14 days after at least 15mm rainfall 21 days after at least 15mm rainfall	
	SURPASS	225g 2,4-D IPA salt/L	up to 1.5L 1.5-3.0L 3.0-4.6L	10 days after at least 15mm rainfall 14 days after at least 15mm rainfall 21 days after at least 15 mm rainfall	
Imidazolinone Imazethapyre	SPINNAKER	240g imazethapyre	200-400ml	22 month + minimum of 800mm rainfall	
Sulfonamide	BROADSTRIKE	800g/kg flumetsulam	25g	3-9 month on permeable soils 24 months on impermeable soils	

CHEMICAL	PRODUCT	ACTIVE CONSTITUENT	APP. RATE PER HECTARE	PLANT BACK PERIOD	COMMENTS
dicamba	DICAMBA 200 BANVEL	200g dicamba/L	up to 0.6L 0.7-1.4L	7 days 21 days	Breakdown of dicamba occurs by microbial activity under moist soil conditions. The nominated plant back period should only commence after there has been in excess of 15mm rainfall
picloram	TORDON 75-D	300g/L 2,4-D 75g/L picloran	300ml-1L	12 months	
	TORDON 242	26g picloram + 420g MCPA/L	1.0L	12 months	
fluroxypyr	STARANE	300g fluroxypyr/L	up to 500ml 500ml-1.5L 1.5-4.0L	14 days 28 days 60 days	Fallow Spray. Mainly used at lower rates of 250-500ml/ha. either alone or in tankmixes with glyphosate.
Triclopyr	GARLON 600	600g trichlopyr/L	80-160ml	7 days	Fallow Spray. Used in tankmixes with glyphosate for the improved control of paddy and camel melons
Clopyralid	LONTREL	300g clopyralid/L	70ml 150ml 300ml	7 days 14 days 56 days	Fallow Spray. Used in tankmixes with glyphosate for improved control of milk thistle.
Oxyflurorfen	GOAL CT	240g oxyflurorfen/L	75-100ml	No plant back period required at the rates specified.	Fallow Spray. While Goal does have soil residual action, the spike rates of 75-100ml used to tankmix with glyphosate should present no soil residue problems in cotton when used as a pre-plant treatment. The chemical provides improved control of prickly lettuce, mallow, medics and stinging nettle.
Atrazine	Various Products	500g atrazine/L	2.5L/ha 2.5-6.5L/ha	6 months 18 months	Damaging residues from high rates of atrazine may persist for up to 18 months depending on weather conditions and soil type. Atrazine is more persistent under the following conditions: - increasing soil pH (alkaline soils) - increasing clay content of the soil - low soil temperatures - low soil moisture levels. Residues persist for considerably longer on alkaline clay soils, and extreme caution needs to be exercised on clay soils where the soil pH is above 8.0. Atrazine breakdown is also strongly influenced by seasonal conditions. Rates of breakdown slow considerably under dry conditions and can stop altogether under extreme conditions such as drought.

By Mike Bange, CSIRO, John Marshall, CSD & Warwick Stiller, CSIRO

Row crop farmers with experience in growing maize, sorghum, sunflowers, soybeans and other summer row crops have no difficulty in adapting to cotton. Land preparation is similar to other summer crops. Compacted fields should be avoided or deep worked early in the land preparation stage. Minimum tillage and tramlining have enormous potential to reduce compaction problems.

While fallowed areas with a full profile of moisture are preferred, 60cm of wet soil at planting is a minimum on the deeper alluvial soils. In the hotter lower rainfall areas, 90cm of wet soil is a more realistic starting level. Obviously, long term climatic indicators such as El Nino should also be considered in conjunction with stored moisture level.

CROP DEVELOPMENT

Temperature is a major factor affecting cotton production. It:

- determines the length of the growing season. Frost will stop the growth of cotton plants, hence the likely date of the first frost in autumn determines the season length.
- has a strong influence on fibre development, particularly on fibre diameter
- directly influences the rate of crop development. At temperatures below 12ºC, cotton development ceases.

The higher the average temperature, the quicker the plant will develop through its major growth stages. A common way of expressing the accumulation of heat over the season is as day degrees, or heat units. The sum of daily day degree values can be used to compare the crop's developmental stage with its potential development.

Table 21: Crop development stages.

Phase	Day Degrees	Days (range)
Planting to Emergence	80	7 to 20
Emergence to First Squares	425	34 to 45
Square to Flower	270	20 to 30
Flower to Open Boll	750	40 to 80
Planting to Crop Maturity		140 to 200

KEY POINTS:

- **Agronomic management of cotton demands a higher level of expertise than is required for alternative crops. Growers must pay greater attention to detail of the timeliness of all operations**
- **Agronomic practices impact on both yield and quality**

Typical values of day degrees to attain some development stages are given in **Table 21**.

Day degrees =

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

When daily minimum temperature falls below 12°C, (Daily min temp – 12) = 0.

VARIETIES

Historically, varieties bred for high yielding irrigated environments have been tested under dryland conditions, and recommendations made based on their performance. CSIRO now have a dedicated dryland breeding program which aims to improve both yield, and stability of yield under dryland conditions.

Considerable research has focused on examining the physiological differences between the okra and normal leaf types. CSIRO research has confirmed results from the USA where okra leaf plants had consistently greater canopy photosynthesis per unit leaf area compared with normal leaf plants. This, coupled with greater photosynthesis rates gave the okra leaf types greater water use efficiency. This increase in leaf productivity and efficiency is an important contributor to the yield advantage of the okra leaf types observed in Australia.

This research also examined the effect of variety maturity on dryland yield. In all seasons the later maturing cultivars performed best. Regression analysis indicated that for every one day increase in cultivar maturity there was a 29kg/ha increase in lint yield. Obviously this yield increase would only continue while the cultivar maturity is less than the available season length. This research relates to medium and full season areas, with normal sowing times. For shorter season areas (such as eastern Downs and Breeza) or late sowings, the medium to early varieties perform best.

Other Considerations

Yields obtained in dryland variety trials vary greatly from season to season due to differing rainfall patterns. Trials can only be assessed with confidence after a number of trials over a number of seasons. It can be misleading to make variety selections based on one year of results.

Since new variety development is very dynamic, information on specific varieties is obtainable from the planting seed companies.

Early orders for cotton seed generally close late July. Most dryland growers prefer to waive the discount which accompanies early orders, and make their varietal selection closer to planting. In this way, they can be assured of planting conditions as well as fine-tuning their variety to the actual time of planting.

Figure 12: Typical skip row configuration used in dryland cotton growing.

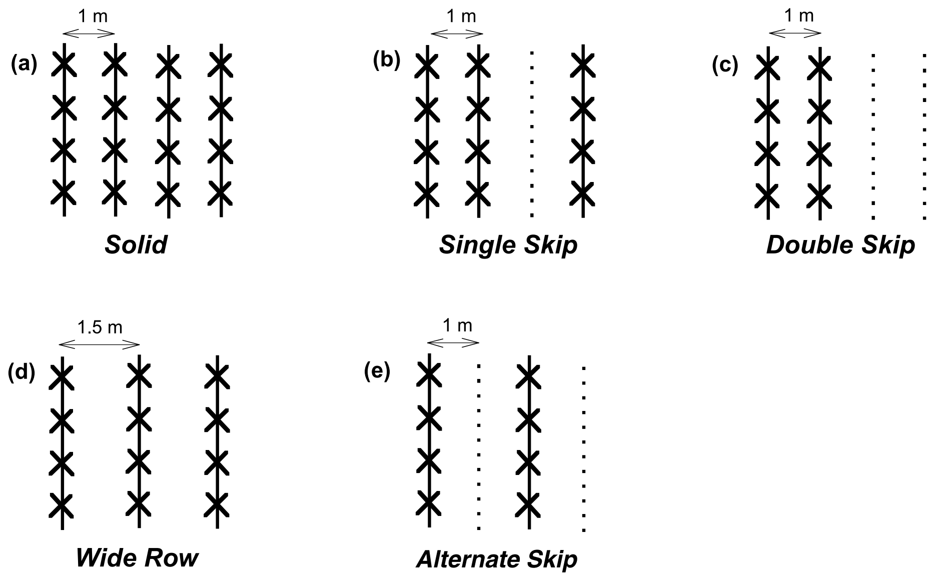
PLANTING CONFIGURATION

One of the management techniques that dryland growers have at their disposal is being able to modify row configuration. Growers can choose to sow their crops using conventional solid row configurations similar to those used in Australian irrigated production, or use configurations that considerably modify row spacing or remove entire rows. Configurations that have entire rows missing from the sowing configuration are often referred to as skip-row configurations. In many cases choice of a row configuration is influenced by each individual farmer’s attitude to risk. The risk is associated in attempting to balance what yield might be forsaken in those years where conditions are suitable for high crop yields versus reducing variable costs and providing some insurance against crop losses through low yields or poor fibre quality in dry years using alternative row configurations.

Choosing a row configuration involves many, often complex, considerations. The choice of configuration can influence the potential yield and risk of production, fibre quality, input costs, machinery set up, and general crop management.

A number of row configurations **(Figure 13)** have been used by dryland growers, with the predominant configurations being solid, single skip and double skip. Other configurations used by some growers include wide row and alternate skip that are essentially solid row configurations with considerably wider row spacings.

Figure 13: Diagrammatic representation of a range of alternative row configurations used in dryland cotton production. Solid lines represent rows with plants present, while dotted lines represent skipped rows.



Mostly the modified configurations aim to provide a reserve of soil moisture beside the planted rows thus extending plant growth during periods of soil moisture stress. In areas where soils have higher soil water holding capacity, solid row configurations are favoured. Conversely where soils have lower water holding capacity and more variable rainfall, skip row configurations are favoured. However, as mentioned previously, growers may often choose different configurations for other reasons.

Water Extraction Patterns in Skip Configurations

There is sometimes concern that crops grown in skip row configurations are not able to extract all water from the skip to depth. Work undertaken by Phil Goyne on the Darling Downs has explored the extraction patterns of dryland cotton under different row configurations (**Figure 14**). His work conclusively showed that in both double and single skip row configurations the crops had water available for a longer time and during critical stages of growth. He also found that moisture at all positions across the skip could be depleted to within the lower limit of plant available water holding capacity (**Figure 14**). Similar results have also been found by Bange and Richards (unpublished data) for a range of soil types in northern NSW.

Cyclic water use patterns may also occur within skip row cotton. Water which is readily available is first extracted from under the plant line and then across into the skip. After this has occurred the plant will concentrate on extracting water at lower depths, back under the plant line before once again utilising the water within the skip.

Yield Potential and Planting 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, 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 the studies by Marshall (1994) (**Figure 15a**) there were no differences when yields were below approximately 2b/ha, while in studies by Goyne (2000) single and double skip configurations actually exceeded solid at low yields (**Figure 15c**). Hearn (1999) combined all the data collected from field experiments and produced a mean response (**Figure 15d**).

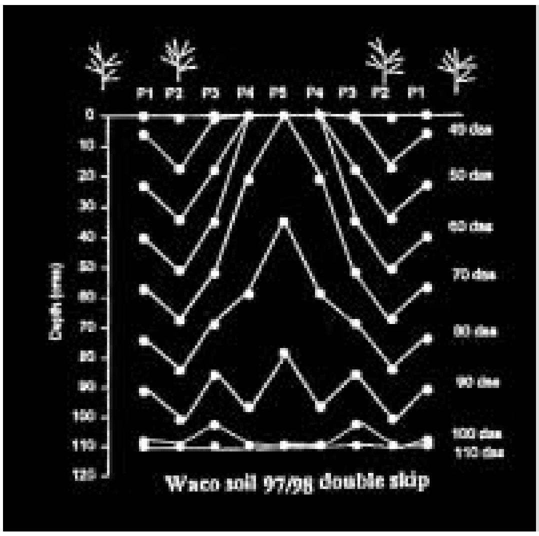
Tables presented in the chapter entitled Dryland Cotton Potential & Risk in this manual use the OZCOT crop simulation model to assess regional potential yield for three different row configurations (solid, single and double).

Planting Configuration and Fibre Quality

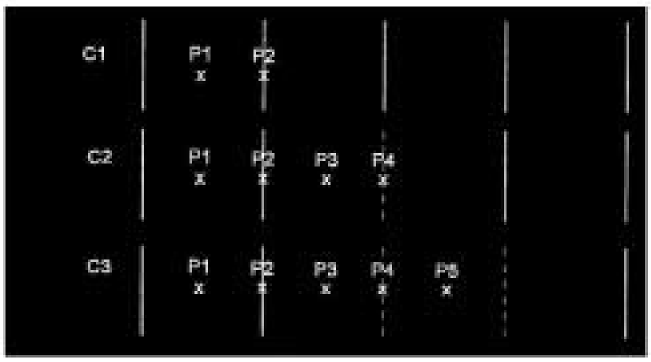
Fibre Development

The production of dryland cotton is generally carried out after a lengthy fallow of 12–18 months duration, in an effort to maximise soil moisture storage, and hence minimise adverse effects of inadequate rainfall during the growth of the crop. Periods of insufficient soil water not

Figure 14: Positions of neutron probe tubes used to measure water extraction in studies and an example of water extraction patterns for double skip (Goyne, 2000).

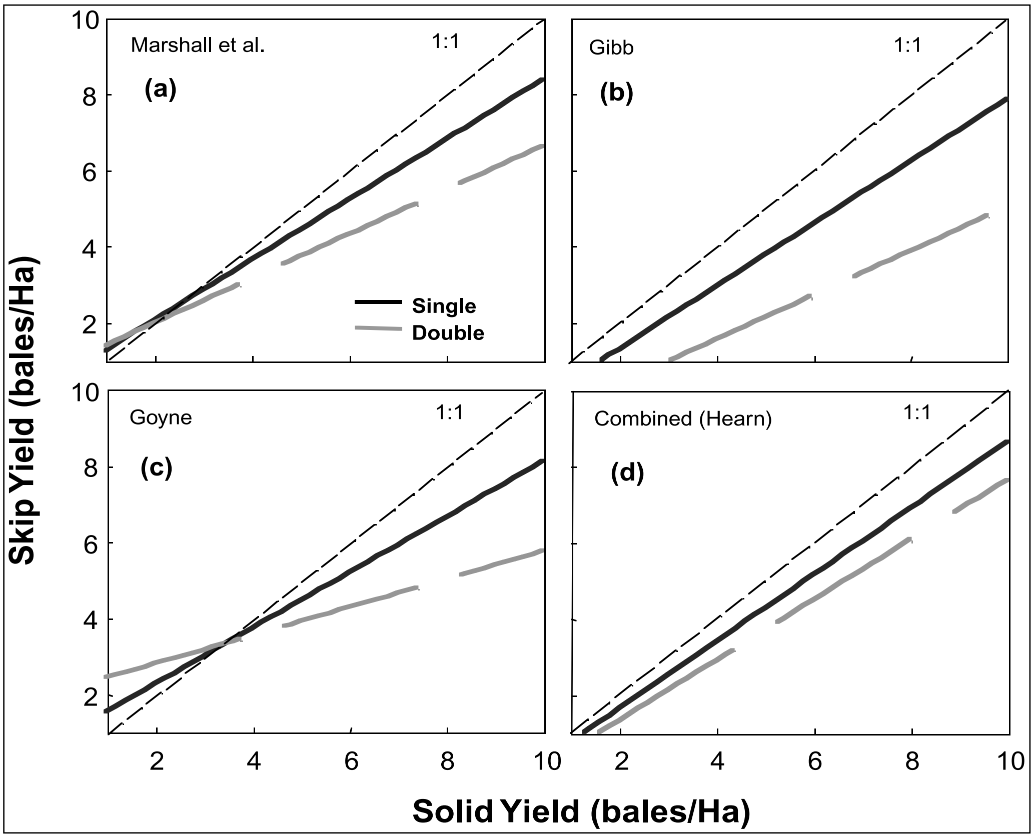


Solid lines are rows of cotton
Broken lines are skipped rows



C1 = Solid, C2 = Single, C3 = Double.

Figure 15: Relationships derived from measured field data that show the relationship of yield of skip row configurations versus solid row configurations. Solids lines are single skip row configurations; broken lines are double skip row configurations.



only reduce the quantity of lint produced but also impact on fibre characteristics, short fibre length historically being the most serious characteristic affected. Achievement of commercially desirable fibre length requires adequate soil moisture during the first 20 days of boll development following flowering. Once length is determined, fibre thickening then occurs.

Seasonal temperature affects crop development and thus causes flowering time to vary between seasons. It is important for fibre development that adequate soil water for crop growth coincides with the time of peak flowering. **Table 22** shows the date of planting, time to first flower and time to peak flower for four years of trial crops grown at Pirrinuan near Dalby in a row configuration trial. (The data in **Table 23** serves to illustrate the extreme variation which can occur in crop development. In this example for both crop yield and fibre length considerations). Growers should aim to have peak flowering corresponding with the period with the highest probability of rainfall, which is late January, early February (similar for all dryland areas). The use of skip row configurations provides some insurance against poor fibre quality at this peak time of flowering by providing a larger soil reserve available to the crop and delaying moisture stress.

Micronaire is another fibre quality characteristic which can vary considerably between seasons, more so in irrigated cotton production than dryland. The desirable fibre for cotton spinners

Table 22: Differences in flowering characteristics of crops in row configuration trial, Pirrinuan near Dalby, in four seasons 1995-1998. (Goyne, 2000)

Year	Variety	Planting date	Days to first flower	Days to peak flower
1995-96	Sicot CS189+	Nov 2nd	73	-
1996-97	Siokra V-15	Oct 11th	102	118 (Feb 6th)
1997-98	Siokra V-15i	Oct 14th	71	100 (Jan 22nd)
1998-99	Siokra V-15i	Oct 8th	83	106 (Jan 22nd)

Table 23: Influence of row configuration on major fibre characteristics in a series of Central Queensland trials. Data from Bruce Pyke, published in Marshall et al. (1994).

Trial location/season	Fibre measurement	Row Configuration: Solid	Single skip	Double skip	Solid yield Bales/ha
Orion 1989/90	Length	D		*	1.4
	Uniformity	*			
	Strength			*	
	Micronaire	D(high)	D(high)	*	
Orion 1990/91	Length	D		*	2.6
	Uniformity			*	
	Strength			*	
	Micronaire		*	D(low)	
Dalby 1991/92	Length	D	D	*	3.6
	Uniformity			*	
	Strength			*	
	Micronaire	D(high)	D(high)	*	
Biloela 1990/91	Length	D		*	5.5
	Uniformity	*			
	Strength		*		
	Micronaire			*	
Biloela 1990/91	Length			*	4.4
	Uniformity			*	
	Strength			*	
	Micronaire	*			

* = best for that characteristic (longest , strongest, most uniform, lowest micronaire >3.5)
D = commercial discount incurred

Table 24: Fibre quality characteristics from two seasons of row configuration trials on Darling Downs QLD (Goyne, 2000)

		Solid	**Single skip**	**Double skip**	
Pirrinuan 1997/98	Yield (b/ha)	3.2	3.4	3.2	No Sig.diff
	Length	33/32	35/32	36/32	Sig. diff
	Strength	30.4	32.9	32.9	Sig. diff
	Micronaire		4.2		No Sig.diff
	Uniformity %		82.8		No Sig.diff
Macalister 1998/99	Yield (b/ha)	8.7	7.6	5.3	Sig diff.
	Length		34/32		No Sig.diff
	Strength		28.6		
	Micronaire		4.2		
	Uniformity %		81.5		

lies in the micronaire range 3.5 – 4.9. High micronaire cotton is most likely to occur in dryland crops in situations when the crop suffers early boll loss, due to either heavy insect pressure or water stress, and then encounters good late season growing conditions. A lot of surplus photosynthate will be deposited in a reduced number of bolls, resulting in much thicker fibres.

Conversely low micronaire cotton can occur if boll setting is delayed, and the crop then encounters lower average temperatures during March-April while fibre thickening is in progress. Skip row configurations can reduce the degree of fruit shedding in crops suffering moisture stress, thereby maintaining a better spread of boll maturity.

Fibre strength is also responsive to soil moisture availability, with lower strength characteristic of crops where some degree of moisture shortage was evident during fibre maturation. Variety has a big influence on fibre strength. Varieties used in Australian dryland production seldom incur a penalty (HVI fibre strength <28gm / tex).

Experimental Comparisons of Row Configuration on Fibre Quality

Two trials conducted in dryland cotton during the last 12 years have examined extensively the influence of row configuration on fibre quality. One trial conducted by Bruce Pyke in Central Queensland early in the 1990's (published in Marshall et al., 1994) showed that there were significant effects of row configuration on fibre quality, especially staple length and micronaire (**Table 23**).

The second study was by Goyne (2000) on the Darling Downs who also measured the impact of row configuration on fibre quality. In some years, fibre characteristics were significantly influenced by row configuration, and in others there was no effect. The experiment in which there was no effect was also associated with high yields and little moisture stress (**Table 24**). Goyne (2000) summarised his results stating 'that length and strength were generally higher for the skip row configurations than the no skip treatments but micronaire was lower'.

Cotton Seed Distributors has also been conducting variety trials at a number of sites in the dryland growing regions over a period of years. **Table 25** below illustrates the fibre length data collected and summarised from ten of these trials, over seasons from 1997 to 2000. Growers at five of the sites used a solid configuration, the other five used skip row.

The data shows that fibre length measured below base grade was recorded in 56% of situations where cotton was grown in solid plant, compared with only 11% with skip row configurations. Furthermore, the degree of shortness of fibres has been much more severe in solid plant with 30% below 33 / 32's (1.03in.), compared with skip where those below base grade fell just below the 35 / 32 (1.09in.) mark.

Table 25: Data on fibre properties of varieties appearing in Cotton Seed Distributors dryland variety trials conducted at ten different sites over four seasons 1997-2000

	Fibre Length Below base				Base	Total
	<1.0	1.00 - 1.03	1.03 - 1.06	1.06 - 1.09	> 1.09	
Solid plant	3	14	20	21	45	103
Skip row	–	–	2	9	86	97
Total						200

Table 26: Discounts for fibre length and micronaire, and corresponding bale price reduction at AUD/USD = 0.50. Period 1996 versus 2001, discounts averaged across merchants

	Fibre length (ins)				Micronaire	
	31 / 32	32 / 32	33 / 32	34 / 32	G4 (<3.5)	G6 (>4.9)
1996 points	-1350	-950	-550	-200	-275	-300
AUD $/bale	135	95	55	20	27.50	30
2001 points	-1650	-1350	-1025	-600	-500	-300
AUD $/bale	165	135	102.50	60	50	30

Table 27: Input cost changes with skip row plantings from Marshall et al. (1994).

Item	% Reduction from solid plant		Comments
	Single skip	Double skip	
Seed	20	33	
Starter fertiliser	33	50	
Soil applied insecticide	33	50	
Water injection	33	50	Time saved in refills
Banded herbicide	33	50	
Early insecticides	33	50	
Late insecticides, defoliants	25	30	Bigger bush
Picking	20-25	33-40	
Mid, late season application	Ground rig use in lieu of aerial application		

An examination of the same data set showed 10 instances of micronaire below base (5% of entries), 9 of these being for solid, and only two instances of high micronaire (1% of entries), both in skip configurations.

Importantly, some consideration of fibre quality issues and their impacts on economics of dryland production systems is necessary when choosing row configurations. **Table 26** highlights the considerable discounts imposed on bale prices with a range of fibre lengths below base grade and micronaires below and above base grade. The table also illustrates the increasing importance that has been placed on producing quality fibre, as shown by the increase in the size of discounts since 1996.

Economics of different row configurations (Yield vs Quality)

Various economic analyses, which include costs of production, are provided by both the Queensland and New South Wales State Government Departments of Agriculture. In many cases there is some financial gain in using skip row configurations, by reducing variable costs, not from increased yields. Marshall et al. (1994) outlined in their paper the approximate differences in production between different row configuration systems (**Table 27**). It is important to note however, that the use of skip row does not always reduce costs. In some cases skip row configurations will require additional use of plant growth regulators, late season insect sprays, and an additional inter-row cultivation or spray for weed control.

While superior gross margins from skip row cotton can be achieved due to savings in variable costs, additional gains (or insurance against losses) can be made by maintaining base fibre quality resulting from the extra soil water available for developing bolls.

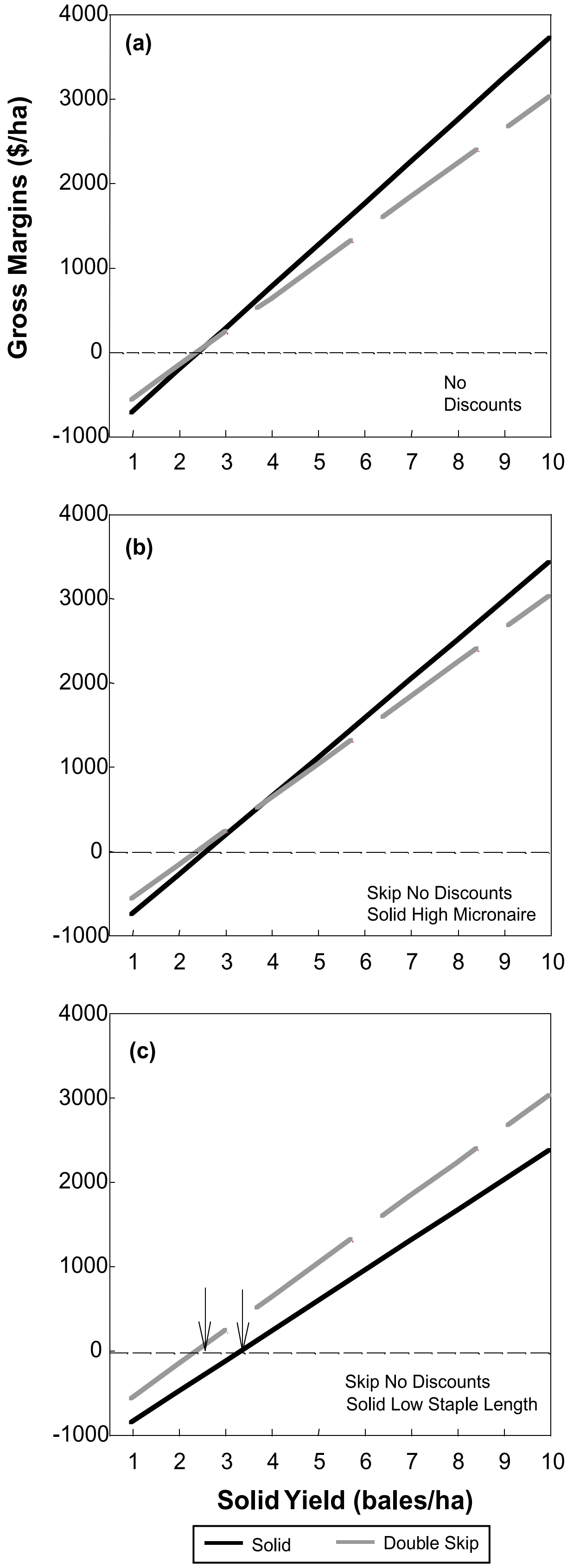
To compare the relative impact of the combined differences in yield, costs of production and fibre quality the following analysis was conducted. Assumptions used in this analysis are outlined below:

Variable costs Solid - $1236.07/ha
Variable cost Double skip - $869.99/ha
Seed return/t seed - $115/t
Lint returns/bale (Ginout 0.37) - $450/bale
High micronaire discount (>4.9) - AU$30/bale
Staple Length discount (32/32) - AU$135/bale
Yield response Skip versus Solid - Combined response (Hearn, 1999; **Figure 15d**, shown previously).

The analysis also assumes that no adjustment for costs is made when expected yields are likely to vary.

The analysis showed that when no deductions for fibre quality were applied, the gross margins for double skip and solid were similar to that of solid configuration at low yields (**Figure 16a**). The divergence in gross margins in this analysis as yields for solid increase is primarily due to the differences in yield potential between solid and double skip configurations as for yield comparisons in **Figure 15d**. When a discount for high micronaire is applied to the solid row configuration the difference in the gross margins between solid and double is less, but not considerably (**Figure 16b**). However, when a discount for low staple is applied for a solid configuration, it has a significant effect on the

Figure 16: Economic comparison of double skip row to solid configuration, accounting for difference in costs and yield. No discounts for quality (a); Discount for high micronaire in solid (b); and Discount for low staple length in solid (c). Arrows in (c) highlight the breakeven yield point.



gross margin compared with double skip (**Figure 16c**). The breakeven yield in this last analysis has moved from approximately 2.5 bales/ha to 3.5 bales/ha. This analysis emphasises the importance of considering quality aspects as well as yield and costs in choosing row configuration.

SEED TREATMENTS

A number of fungicides and insecticides are registered for use as seed treatments on cotton. Pre-treated seed can be purchased from your distributor. The seed treatments provide some insurance against damage or loss of seedlings. Early plantings into cool and wet soils slow plant development and make seedlings more prone to damage from disease and sucking insects. The treatments are less important with late plantings into warmer soils.

Fungicides

PCNB (Quintozene®, Terrachlor®)

– active against Rhizoctonia spp.

(Apron®, Mantle®)

– systemic fungicide active against Phythium and related species of fungi which cause 'damping off' of seedlings

Insecticides

Thiodicarb (Semevin Super®)

– provides systemic thrip control for up to 10 days after emergence

Imidacloprid (Gaucho®)

– provides systemic thrip control for up to 21 days after emergence

Thiamethoxam (Cruiser®)

– provides systemic thrip control for up to 21 days after emergence

Seed colouring

The polymers, Peridiam (blue, green, red, violet) on CSD seed and Nacret (blue, green) on Deltapine seed are used as seed coatings. They enhance the application and effectiveness of fungicides and insecticides, improve seed flow, and leave a unique colour on the seed which improves seed visibility and allows both planting depth and rate to be easily checked.

PLANTING

Considerations

Soil temperatures should be > 15.5ºC at 10 cm depth at 8.00 am.

Earlier plantings under cooler soil temperatures result in poorer establishment, slower development and greater vulnerability to seedling insects and diseases

Later plantings risk having cooler autumn

Table 28: Regional planting times.

	Northern NSW, Darling Downs, Sth West Qld	Central Highlands	Liverpool Plains
Preferred	early October to mid November	mid November to late December	early October to mid November
Latest	early December	mid January	late November
Earliest	late September	late September (high risk)	late September

conditions which affect fibre development. Insecticide costs may also be higher as a greater number of expensive Stage III sprays may be required.

Plant Populations

The recommended plant population in all dryland row configurations is 7 to 8 plants/m of row. It is even more desirable to have these plants evenly spaced. Plant populations that are too high may reduce yield by encouraging excessive plant competition, while plant populations that are too low, even when evenly spaced may sacrifice yield, encourage excessive growth and cause difficulties at harvest.

Marshall et al. (1994) explored the impact of plant population within the row with different row configurations over a number of experiments. Results showed that there was a high degree of flexibility in the plant population in the row before yields were affected. Results of single skip configuration experiments, which was their most comprehensive data set, showed that there was no consistent relationship between plant population and final crop yield (**Figure 17a**). When the yield data were made relative to the maximum yield in each experiment it again showed there was no consistent response and highlighted the flexibility of plant population (**Figure 17b**). In the range 5 to 15 plants there was no instances where low yields were related to plant densities in the row. Goyne (2000) also found no effects of in row plant population on yield.

In general, dryland cotton has a lower potential to compensate for gappy stands. Little data exists on the impact of gappy stands in dryland cotton, but if replanting is considered the same principles as for irrigated production would apply. Research suggests that replanting be considered when gaps bigger than 50cm constitute 20% of the stand.

Desirable: 7-8 plants/metre row

Equivalent: 45,000 to 55,000 plants/ha (single skip).

Considerations:

– Evenness of the stand is more critical than the absolute population achieved. A gappy stand is difficult to manage due to the large range in plant size. Yield reduction and delayed maturity may also result.

– Trials suggest that row configuration has little effect on the desirable number of plants per metre. In practice, however, growers are generally satisfied with 4 to 5 plants per metre of row on solid row configurations.

A step by step procedure for working out quantity of seed required, using **Table 29**, follows:

Figure 17: Relationships of single skip row configuration yields versus in row plant population (plant /m of row) (a) and the relative yield (to the maximum measured) for a range of experimental sites.

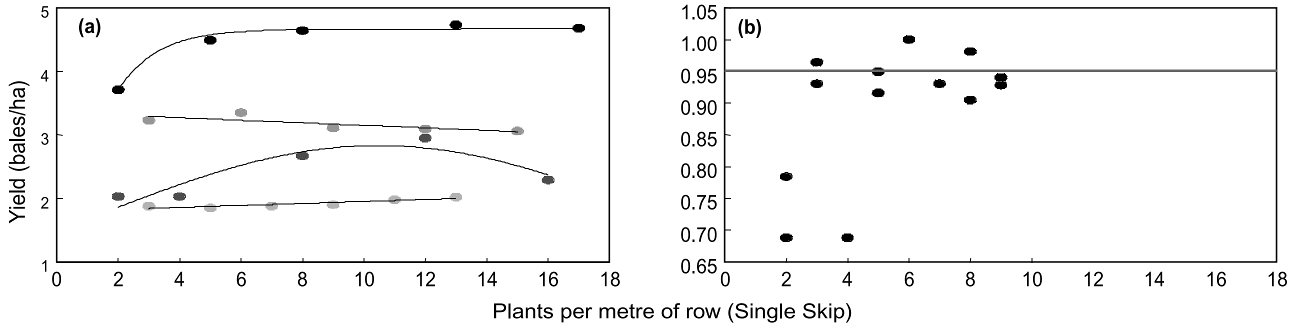


Table 29: Seed quantity required.

Plant Stand Required plants/m	Solid Plant kg/ha	Single Skip kg/ha	Single Skip + Tram Line kg/ha	Double Skip kg/ha
4	5.9	3.9	3.7	3.0
5	7.4	4.9	4.6	3.7
6	8.9	5.9	5.5	4.4
7	10.3	6.8	6.4	5.1
8	11.8	7.8	7.3	5.9
9	13.3	8.8	8.2	6.6
10	14.8	9.7	9.1	7.4

1. Decide what final plant stand you want per metre of row.
2. Move across the table until you find the appropriate planting configuration.
3. Multiply the number obtained by the paddock size (ha). This will give the total quantity of seed (kgs) required.

Example:

Plant stand required is 7 per metre

From single skip column, seed quantity required per ha is 6.8kg

If paddock size is 120ha, total quantity of seed is 6.8 x 120 = 816kg (41 bags)

Table 29 uses the following assumptions:
1 metre row spacing
90% germination
75% establishment
average seed size (10000 seeds/kg)

Actual germination percentage can be obtained from the seed companies. Rates should be adjusted for the prevailing conditions.

Planting depth

Cotton is very sensitive to both depth of soil and soil pressure above the seed. Seed planted deeper than 5cm may fail, or at best be very slow to emerge. Such a delay can set the plant back significantly, making later management and crop conditioning operations very difficult.

Table 30: Insecticides/Fungicides at planting (rates in kg/ha).

Product	TEMIK 150 G	Chlorpyrifos	THIMET 200 G
Method of Application	in-furrow granules	in-furrow spray or bait	in-furrow granules
Aphids	3 - 7	-	3
Jassids	3 - 7	-	3
Mites	3 - 7	-	3
Thrips	3 - 7	-	3
Mirids	5		5
Earwigs		5 kg Bait mix/ha*	
Crickets		2.5 kg Bait mix/ha*	
Wireworms		in-furrow spray 5-15 mLs/100 m row	
False wireworms		in-furrow spray 5-15 mLs/100 m row	

Chlorpyrifos grain bait: Mix 4L Chlorpyrifos (500g/L) + 5L sunflower oil.

Excessive presswheel pressure, large lumps of pressed soil, or crusting due to heavy rainfall can all seriously affect emergence, as the young cotton shoot must push the seedling leaves through the surface layer. Therefore, 4–5cm depth of planting, with light presswheel pressure or rolling, good soil tilth and the seed sitting in moist soil are the recommendations for good emergence.

Considerations

- Wireworms and false wireworms can be a major problem for all wide row planted summer crops. These soil dwelling insects are best controlled with in-furrow treatments at planting. Treatment after planting is impractical.
- Assess numbers of wireworm and false wireworm prior to planting using soil samples. Control is warranted where significant numbers exist, especially in association with unfavourable establishment conditions, e.g. cool or dry seedbeds.
- The granular insecticides Temik, and Thimet® are registered to control sucking insect pests on seedling cotton. They are not widely used in dryland production. (see **Table 30**)
- Rhizolex, is registered for the control of Rhizoctonia (a seedling disease). Plantings into cool, wet soil, particularly following soybeans, are most likely to be affected. The seed treatments Quintozene and Terrachlor should provide adequate protection in most dryland situations.

NUTRITION

Nutrient requirements

Table 31 indicates that N, P, and K are the nutrients most likely to be deficient, limit crop growth and may require the addition of fertiliser. Zinc is the only other nutrient to which fertiliser responses have been documented in dryland cotton.

Fertiliser

In general, dryland cotton is fertilised similarly to other summer crops, although cotton's root system may access nutrients at greater soil depth. Fertiliser is generally used with dryland cotton on the Darling Downs, less so in other areas.

When deciding on fertiliser rates for dryland cotton, consider the following:

- rotational history of the field. Requirements are greater following sorghum or cotton than after a long fallow from a cereal or legume crop
- responses to fertiliser in other summer crops
- responses to fertiliser in dryland cotton on similar soils in the district
- Soil tests should be taken
- Some growers use the petiole nitrate test

Fertiliser rates commonly used in dryland cotton are listed below:

- 30 to 80kg N/ha depending on soil moisture and above factors
- 5 to 15kg P/ha on soils responsive to phosphorus.

Table 31: Nutrient removal rates and uptake by 2.5b/ha cotton crop

Major Nutrients	Removal in lint + seed (Kg/ha)	Total uptake (Kg/ha)
Nitrogen	28	47
Phosphorus	5	13
Potassium	15	75
Calcium	3	50
Magnesium	3	20
Sulphur	0.2	6

Micronutrients	Removal in lint + seed (g/ha)
Zinc	0.03
Manganese	0.03
Boron	0.05
Copper	0.008
Iron	0.17

Reference: Constable, G. (1988) ACGRA Conference

Zinc and phospohorus mixes are used by some growers at planting time as a way of reducing potential long fallow disorder problems, and topping up zinc levels on older, high producing soils.

Timing and placement

• Nitrogen is generally applied pre-sowing either broadcast and incorporated or banded. It should be delayed until late in the fallow, especially if the profile is full of soil moisture, to reduce the risk of loss by denitrification. In reduced tillage systems, banding may be preferable but this relies on good tramlining systems.

• The band should be located at least 10cm below the anticipated seeding depth to avoid the detrimental effect of high nitrogen concentrations on seed germination.

• Some farmers apply an excessive amount of N to their cereal crop which allows a residue of N to be available to their next cotton crop.

• Phosphorus is relatively immobile in the soil and hence placement is critical. If applied at planting, it should be placed 5cm to 10cm below and to the side of the seed.

• Zinc deficiency can be corrected by incorporating fertiliser pre-sowing or at-sowing, or with foliar treatments.

REFERENCES

Constable, G., Eveleigh, R., Kay, A. and Marshall, J. (1997). Replanting Guide. Cotton Seed Distributors, Wee Waa, Australia.

Gibb, D. (1995). Cotton Production During Drought. Cooperative Centre for Sustainable Cotton Production. Narrabri, Australia.

Goyne, P. (2000). Improved understanding of cotton water use for better management in water limited environments. Final Report submitted to Cotton Research and Development Corporation and Queensland Department of Primary Industries.

Hearn, B. (1990). Prospects for rain-fed cotton. Proceedings of the 5th Australian Cotton Conference. Broadbeach QLD. ACGRA. pp.135-144.

Marshall, J., Pyke, B. and Castor, P. (1994). Managing risk with row configuration and plant density in raingrown cotton. Proceedings 7th Australian Cotton Conference. ACGRA. pp.221-228.

Figure 18: Side-dressing nitrogen into a no-till field at the CRC's dryland farming systems trial at Warra

By Graham Charles, NSW Agriculture

A sustainable system for dryland cotton production will include a well developed weed management program. Weed management is an important issue for Australian cotton production, and requires a dedicated, long-term approach. This is especially the case with dry-land cotton, where cropping flexibility is essential, and where each cotton crop will probably be preceded by and / or followed by cereal or other crops. The selection of weed management tools will be made on a year-by-year and field-by-field basis, but must still be made within a long-term farm plan, as decisions made in any one year will impact on options for future years. *Refer to WeedPAK.*

KEY POINTS:

- **An effective integrated weed management system cannot be isolated to a single crop. It must include rotation crops, fallow, non-cropped areas, fencelines, roads & buildings, using all weed management tools available.**
- **Cotton is highly sensitive to phenoxy type herbicides, such as 2,4-D.**

WEED COMPETITION

Weeds can be very competitive, and can have a big impact on crop production. If left unmanaged, a heavy weed population has the potential to out-compete a crop, with the result that no harvestable crop is produced.

All seedlings exploit water and nutrients virtually from the moment they emerge from the soil, although seedlings initially have very limited requirements. Cotton seedlings are often slow to emerge from the soil and will grow slowly in cool spring conditions. This can leave a large window for weed competition. Weeds may emerge with the cotton and grow far more quickly than the cotton, enabling the weeds to shade the shorter cotton seedlings, and to exploit water and nutrients from deeper in the soil than is available to the slower growing cotton. This is particularly a problem in dryland cotton production, where soil moisture and cool temperatures can be major limiting factors.

The extent of resource use rapidly increases as weeds grow. Yield reductions due to weed competition have been recorded from weeds as soon as 4 weeks after cotton emergence. There is no recordable reduction in cotton yield when weeds are removed before 4 weeks of age. However, the length of this critical period of competition depends on a range of factors, including the growth rate of the weeds and cotton, and the scarcity of resources. Ideally, weeds should be controlled during the critical period, before the weeds become well established and begin to compete strongly with the cotton.

To achieve maximum cotton yields, weed control will need to be maintained for at least 10 to 14 weeks after cotton emergence. Older, well-grown cotton plants have a large leaf canopy and a deep and extensive root system that enables them to be very competitive, shading the soil surface and exploiting soil resources to depth. Consequently, weeds that emerge late in the season have no measurable impact on the cotton yield. These late emerging weeds may still be very important, however, as they can contaminate cotton lint, and may produce large amounts of seed that may contribute to major problems in latter years.

In some situations, particularly with limited rainfall, dryland cotton plants may be very small and may not develop sufficiently to be able to compete strongly with weeds. When this occurs, weeds that emerge from late summer rains can still have a direct impact through competition for soil moisture.

In skip-row cotton, weeds that emerge in the non-planted skip-rows require long-term control. With no cotton planted in these rows, these weeds are not competing directly with the cotton early in the season and so may be tolerated for longer than weeds growing directly in the cotton plant line. However, as these weeds grow, they begin to utilise resources required by the cotton later in the season, and so compete directly with the cotton. Mid- and late-season control of these weeds is important.

Weeds also impact on cotton production in a variety of other ways, and may be hosts of cotton pests and diseases. This is particularly important in managing INGARD cotton crops, where Heliothis caterpillars can grow and develop on weeds such as bladder ketmia, pigweed and the senecios, and can then move on to the cotton. Volunteer cotton can itself be a 'weed' in cotton; volunteer conventional cotton is a problem in Ingard cotton particularly, where it acts as a host to heliothis grubs. Cotton diseases may carry over on weeds, but many weeds are also hosts for vesicular arbuscular mychoriza (VAM) and other beneficial soil microorganisms.

In addition, weeds have the potential to adversely affect crop harvestability and cotton lint quality. Large weeds such as thornapples, noogoora burrs and sesbania can obstruct or damage cotton picker heads, potentially leading to expensive breakdowns. Vines such as cowvine, bellvine and spineless caltrop can also tangle in picker heads, leading to significant down-time as heads are cleaned. All weeds also have the potential to contaminate cotton lint. Grass weeds, such as blow-away grass, are a major problem, as grass fibres are difficult to remove from lint. Consequently, weeds that emerge late in the season may still need to be controlled, as they can have a large impact on cotton harvestability and lint quality, even though they emerge too late in the season to affect cotton yield.

WEED IDENTIFICATION

Common names for weeds vary quite significantly from area to area and can create confusion when discussing control options.

In order to avoid misinterpretation in this document, the common names accepted by Shepherd, Richardson and Richardson (2001) are given precedence over other common names. Some of the more commonly used alternative names are shown in **Table 32**.

Accurate weed identification is important to good weed management. While inter-row cultivation does not particularly discriminate between weeds, most of the herbicides are more effective on some weeds than on others.

Accurate identification is essential for correct herbicide selection and to enable selection of appropriate herbicide rates. Plants are most readily identified by their flowers, although positive identification of younger plants can be made in many instances.

Assistance in identification is available from NSW Agriculture and QDPI Agronomists, as well as most cotton consultants and chemical company representatives.

Where this fails, identification of flowering plants can be given by the herbariums attached to the Botanical Gardens in each state.

Table 32: Some weeds that are easily confused, or have more than one commonly used name.

Preferred Common Name	Scientific Name	Other Names
Annual ground cherry	*Physalis ixocarpa*	Physalis, Gooseberry, Chinese lantern
Wild gooseberry	*Physalis minima*	Physalis, Gooseberry
Bellvine	*Ipomoea plebeia*	Morning Glory
Cowvine	*Ipomoea lonchophylla*	Peachvine
Bladder ketmia	*Hibiscus trionum*	Wild Cotton
Caltrop	*Tribulus terrestris*	Cathead, Bullhead
Spineless caltrop	*Tribulus micrococcus*	Yellow vine
Caustic weed	*Chamaesyce drummondii*	Caustic creeper, Flat spurge
Black bindweed	*Fallopia convolvulus*	Climbing buckwheat
Jute	*Corchorus olitorius*	Native Jute
Legumes: • Emu-foot	*Cullen tanex*	Wild Lucerne, Native Lucerne
• Rhynchosia	*Rhynchosia minima*	Rhyncho
• Sesbania pea	*Sesbania cannabina*	Yellow Pea-Bush
Melons: • Wild melon	*Citrullus lanatus*	Afgan melon, Pie melon, Camel melon
• Prickly paddy	*Cucumis myriocarpus*	Paddy melon
Small-flowered mallow	*Malva parviflora*	Marshmallow

INTEGRATED WEED MANAGEMENT

A successful integrated weed management system must be flexible and able to respond to constantly changing needs. It should use a range of different management tools, selecting economically and environmentally appropriate tools to maintain a sustainable farm system. Where possible, tools should be used that effectively achieve the desired outcome, with minimal detrimental impact on the system, and especially on cotton and rotation crops. Heavy reliance on one set of management tools, such as herbicides or cultivation, can result in a system that is effective in the short-term, but is not sustainable in the long-term.

WEED MANAGEMENT TOOLS

Weed management can be achieved using a combination of the following tools:

- Weed control in fallow
- Crop rotations
- Herbicides
    - pre-plant treatments
    - post-plant treatments
        - over the top
        - directed sprays
        - shielded sprays
    - pre-harvest treatments
    - spot spraying
- Transgenic, herbicide tolerant cotton varieties
- Inter-row cultivation
- Manual weeding using chippers
- Attention to machinery hygiene.

Selection of the ideal combination of weed management tools should be made on a year-by-year and field-by-field basis. Factors such as the expected weed pressure and diversity, expected cotton price and yield, available soil moisture, field history, planting configuration, available equipment and personnel, and previous experience all affect weed management decisions.

The cotton grower must always weigh up the need for weed control against the cost of control. This cost can be measured in terms of the actual cost of the control measures, in terms of the cost of the damage caused to the cotton or other crops by the control measures, and in terms of the impact of control on future management decisions. This possible future cost can be easily overlooked, but is important, as a control measure used now can negatively impact on other current or future options.

Most control measures cause some damage to cotton. Inter-row cultivation, for example, prunes some cotton roots and so damages the cotton plant. Similarly, most herbicides cause some damage to the cotton. In all cases, the key to effective control is timeliness of application and the use of appropriately set up equipment.

Weed control in fallows

Generally, weed management in the fallow prior to cotton is the easiest and most cost effective form of weed control. Normally, a field to be planted to cotton will be fallowed for about 12 months prior to cotton planting, allowing an extended opportunity to conserve soil moisture and to control summer and winter weeds. Although many weeds produce ‘hard’ seeds that are able to survive in the soil over a number of years, the vast majority of the weed seed-bank can be run down very quickly simply by maintaining a weed-free fallow over this period.

When fallows are maintained using herbicides, this strategy has the added advantage of retaining stubble cover and maximising the retention of soil moisture. Maintaining stubble cover is an essential strategy for minimising soil loss through erosion on fields with slope, and fields prone to flooding and water movement.

Rotation Crops

Rotation crops can be valuable for managing weeds, as a different range of herbicides is available for use in rotation crops. Some weeds that are difficult to manage in cotton can be more easily managed with different herbicides in a rotation crop. This is particularly the case for cereal crops, where most broad-leaf weeds can be readily controlled in-crop. It is less true of the broad-leaf crops, where broad-leaf weed control can be a major problem.

Attention to potential herbicide drift problems and plant-back information is vital when considering the use of non-cotton herbicides both in fallows and in rotation crops. Specific information on re-cropping intervals to cotton is covered in **Table 20** (see pages 40).

Pre-Plant Residual Herbicides

A range of residual and non-residual herbicides is available for use in cotton, as shown in **Tables 33, 34 and 35**. The residual herbicides often give the more cost-effective weed control, but have other draw-backs. In the cooler areas, where there is only a relatively short sowing window, cotton growers should carefully consider their choice of pre-planting residual herbicides. These herbicides may need to be applied prior to cotton planting, and should a planting opportunity fail to eventuate, the herbicides already applied may preclude planting of an alternate crop at a later date.

Trifluralin and diuron are examples of relatively inexpensive yet effective herbicides often used with cotton, but which greatly reduce the grower's planting options, should cotton not be planted. Minimum re-cropping intervals for the cotton herbicides are shown in **Table 36**. Judicious use of soil residual herbicides enable growers to consider other crop options for a December-January planting, such as sorghum, sunflower, and mung beans.

One strategy to avoid problems with pre-plant residual herbicides is to band the herbicide, so that herbicide is applied to the cotton row, but a band of untreated soil remains in the inter-row area. Weeds that emerge in this area can then be managed using cultivation, and a residual herbicide may be applied later in the season. However, should the cotton fail, an alternate crop can be safely planted in the untreated band. This strategy is best suited to fields where permanent wheel tracks are established or where the skip-row planting configuration is used. In these systems, the cotton-row and inter-row areas are well defined, allowing herbicides to be banded and alternate crops to be planted into the untreated band.

Residual herbicides applied at or post planting, may still cause problems in the event that the cotton crop fails to establish or is hailed out. All residual herbicides also have the potential to cause problems for the crop that follows cotton, as indicated in **Table 36**. This data has been developed in consultation with the grochemical industry and is intended only as a guide. The re-cropping intervals listed should be modified to suit local seasonal conditions and soil type variations.

Post-Plant Non-Residual Herbicides

Residual herbicides have the advantage that they are present and active from the time of application, but the disadvantage that they are normally applied in anticipation of a weed problem, and may not be necessary. The non-residual herbicides have the advantage that they can be applied as needed, but they will only control weeds present at the time of application. Multiple applications are often required to control sequential germinations of weeds, as herbicides are most effective on small weeds. Higher herbicide rates are required to kill larger, established weeds, and some large weeds may not be controlled at all, even at the highest registered herbicide rates.

A weed control program based on non-residual herbicides may need to be repeated every 3 or 4 weeks to control successive weed germinations. Such a program may be prohibitively expensive and impractical due to time and labour constraints. A period of wet or windy weather can be disastrous for a weed control program based solely on non-residual herbicides.

Some of the non-residual herbicides have the added disadvantage that although they do not give residual control of weeds, they still persist in the soil for long periods of time, and so still have plant-back restrictions to other crops.

Ideally, a weed management program will include some residual herbicides, supplemented by non-residual herbicides as needed. Shielded sprayers and spot sprayers are valuable for removing weeds from the inter-row area. Spot sprayers are particularly valuable for managing low densities of larger weeds.

Nevertheless, no herbicide is completely safe on cotton. All herbicides cause some damage to cotton and will probably delay crop maturity to some extent. These effects are minimised when the herbicides are applied correctly, and are normally much smaller than the impact of not controlling the weeds.

Herbicide Guide

A guide to the weeds controlled by the herbicides registered for use in cotton is provided in **Tables 33, 34 and 35**. Further information on herbicides, application rates and application details is provided in the *Cotton Pest Guide*, published each season. However, this information is a general guide only. Specific directions for pesticide use are provided on the product label and must be complied with.

Transgenic Cotton Varieties

A range of transgenic, herbicide tolerant cotton varieties may become available over the next few years. Of these, only glyphosate tolerant (Roundup Ready®) cotton is currently available.

Roundup Ready® cotton has been genetically modified to enhance its tolerance to glyphosate. Except for this change, the plant is the same as conventional cotton. Glyphosate can not be applied over-the-top of conventional cotton varieties, although it can be applied to the inter-row area through a shielded sprayer. Roundup Ready® cotton is tolerant of glyphosate applied over-the-top only during early plant growth. Beyond the cotton 4 true-leaf growth stage glyphosate must still be applied as a directed spray, or through a shielded sprayer so that the herbicide does not contact the cotton foliage.

The Roundup Ready® technology allows cotton growers to substitute glyphosate for some residual herbicide applications, reducing potential re-cropping problems. Glyphosate is also valuable for managing some of the weeds (such as nutgrass), which are difficult to control in conventional cotton.

Inter-row cultivation

Inter-row cultivation is a relatively cheap and effective method of removing weeds from the inter-row area, and is particularly valuable for managing weeds in skip-row cotton. However, some soil moisture is lost through each cultivation pass, and some pruning of cotton roots may occur, damaging the cotton plants. Inter-row cultivation also exposes the soil surface, leaving the soil more vulnerable to erosion. Ideally, cultivation should cause minimal surface soil disturbance, leaving surface residues largely undisturbed. This is particularly important on sloping, erosion prone fields.

To be effective, inter-row cultivation should occur before weeds become too large, and should be timed to occur as the field is drying down after rain. Cultivation should be delayed for a few days after rain, as many weeds will not be killed but simply transplanted by a cultivator operating in a wet soil. Soil compaction is also another very undesirable outcome of cultivating wet soil. However, cultivating in dry conditions can cause excessive damage to young cotton seedlings, particularly in a blocky or compacted soil.

Hand chipping

Manual weeding by hand chipping is a valuable tool for removing low densities of weeds from the cotton plant line. It is especially valuable for removing weeds which escape other forms of control. Hand chipping can be extremely expensive. Chipping should be used in conjunction with inter-row cultivation or shielded spraying, so that the majority of weeds are removed by the cultivator/spray, at much lower cost than chipping. Care should be taken to ensure that the cost of chipping does not become excessive.

Machinery Hygiene

Weeds spread through a variety of mechanisms, generally through the dispersion of seeds, primarily by wind, water and animals. Most weeds produce large numbers of seeds, each of which is capable of producing a new plant. Some weeds are also capable of reproducing vegetatively, spreading through tubers, rhizomes or stolons, and some are capable of regrowing from a piece of leaf or section of stem.

Apart from the natural means of weed dispersion, one of the most common villains for spreading problem weeds is the cotton grower himself. This spread normally occurs via contaminated equipment such as cultivation equipment, pickers and farm vehicles. Good machinery hygiene is essential to avoid introducing new weeds and diseases from other contaminated fields or from other areas. Machinery from off-farm should always be thoroughly cleaned down before use. It is also sound practice to clean down machinery before it travels from one field to another.

Weed Susceptibility to Herbicides

The weeds listed in **Tables 33, 34 and 35** have been rated according to their susceptibility to the various herbicides under average to good conditions. Since the level of control is influenced by rainfall, seedbed soil conditions, and other environmental factors, there is no guarantee that a treatment will give the result indicated in these tables.

As a general guide, weeds are most susceptible to herbicides when the plants are actively growing. Any form of stress (such as moisture stress, temperature stress, low humidity and low light) can reduce herbicide efficacy, although some herbicides are more robust than others. Weeds are also most easily killed when they are small; large weeds can be very difficult to control.

The efficacy of residual herbicides is closely linked to soil moisture content, as these herbicides are taken up by the plant through soil water. Most herbicides are ineffective in dry soil.

ALWAYS READ THE LABEL OF THE PRODUCT BEFORE USE, as the best information on any given product will be on the label. The information in this article is intended as a guide only.

Product registrations vary between states and label information must be complied with. The label will supply additional information on product safety and use constraints, application rates and timing, the use of surfactants, soil incorporation, water rates, nozzle pressure and configuration, product compatibilities, and equipment decontamination, as well as other information pertaining to the product and its use.

More detailed information on the components of an integrated weed management system is provided in "*Integrated Weed Management Guidelines*" in WeedPAK.

Table 33: A guide to the weeds controlled by soil residual herbicides.

Active ingredient* Herbicide Group	trifluralin 1.4-2.8 L/ha D	pendimethalin 3.5-4.5 L/ha D	metolachlor 2 L/ha K	fluometuron 4.5-6.0 L/ha C	prometryn 3.3-4.5 kg/ha C	fluometuron + prometryn 3.5-5 L/ha C
GRASS WEEDS						
Annual grasses general	S	S	S	MS	MS	MS
Barnyard grass	S	S	S	MS	MS	MS
Johnson grass from seed	S	MS	MS	PS	T	T
Nutgrass	T	T	T	T	T	T
Liverseed grass	S	S	S	MS	MS	MS
Volunteer cereals	MS	MS	MS	S	S	S
Volunteer sorghum	S	S	S	S	S	S
BROADLEAF WEEDS						
Amaranthus	S	S	PS	S	S	S
Annual ground cherry	T	T	T	S	S	S
Anoda weed	T	T	T	-	-	-
Australian bind weed	T	T	T	T	T	T
Bathurst burr **	T	T	T	S **	S **	S **
Bellvine	T	T	T	MS	S	S
Black bindweed	MS	T	T	-	S	MS
Blackberry nightshade	T	MS	PS	S	S	S
Bladder ketmia	T	T	T	S	S	S
Caltrop	S	MS	PS	S	S	S
Caustic weed	T	T	T	S	S	S
Cowvine	T	T	T	MS	S	S
Deadnettle	MS	T	PS	S	S	S
Devil's claw	T	T	T	T	MS	S
Emu-foot	T	T	T	T	T	T
Jute	PS	-	PS	MS	MS	MS
Mintweed	MS	MS	MS	MS	S	S
Mung bean **	T	T	T	MS	T	MS
Native rosella	T	T	T	S	-	S
Native vigna	T	T	T	-	-	-
Noogoora burr **	T	T	T	S **	S **	S **
Parthenium weed	T	T	T	S	S	S
Pigweed	S	S	T	S	S	S
Polymeria takeall						
Prickly paddy melon	T	T	T	S	S	S
Raspweed	T	T	T	-	-	-
Rattlepod	T	T	T	S	S	S
Rynchosia	T	T	T	-	-	-
Sesbania	T	T	T	MS	MS	MS
Small-flowered mallow	T	T	T	T	T	T
Sowthistle	T	T	T	S	S	S
Spineless caltrop	S	MS	PS	S	S	S
Sunflower **	T	T	T	S **	MS	MS
Thornapples **	T	T	T	S **	S **	S **
Wireweed	S	S	PS	-	S	MS
Wild gooseberry	T	T	T	S	S	S
Wild melon **	T	T	T	S	S	S
Wild turnip	T	T	T	-	S	-

S Susceptible, MS Moderately susceptible, T Tolerant, PS Some activity, – Not known

*** These herbicides are listed by active ingredient, as they are available from a range of Chemical Companies, under a variety of trade names.**

**** Because of their large seed size, these weeds may germinate below the herbicide band, reducing the level of control achieved.**

Table 34: A guide to the weeds controlled by herbicides.

Active ingredient (or registered trade name®) Herbicide Group	diuron 1.8-3.5 L/ha F	Zoliar®** 2-4 Kg/ha F	Staple® 30-120 g/ha B	MSMA 1-2.8 L/ha K	glyphosate 450*** 1-2 L/ha M
GRASS WEEDS					
Annual grasses general	MS	MS	T	S	S
Barnyard grass	MS	MS	T	S	S
Johnson grass from seed	T	MS	T	MS	S
Nutgrass	T	MS	T	MS	MS
Liverseed grass	MS	MS	T	S	S
Volunteer cereals	S	MS	T	-	S
Volunteer sorghum	MS	MS	S	MS	S
BROADLEAF WEEDS					
Amaranthus	S	T	S	T	S
Annual ground cherry	MS	T	S	T	S
Anoda weed	-	T	S	T	MS
Australian bind weed	-	T	T	T	MS
Bathurst burr	S*	T	S	S	S
Bellvine	MS	T	S	T	PS
Black bindweed	-	T	T	T	MS
Blackberry nightshade	S	T	-	T	MS
Bladder ketmia	MS	T	T	T	MS
Caltrop	MS	T	T	T	S
Caustic weed	MS	T	T	T	S
Cowvine	T	T	S	T	MS
Deadnettle	S	T	T	T	S
Devil's claw	-	MS	T	T	S
Emu-foot	-	T	T	T	MS
Jute	PS	-	T	T	S
Mintweed	MS	T	T	T	S
Mung bean	MS	T	T	T	S
Native rosella	-	T	T	T	MS
Native vigna	-	T	T	T	S
Noogoora burr	S*	T	S	S	S
Parthenium weed	S	T	T	T	MS
Pigweed	S	T	T	T	S
Polymeria takeall	T	T	T	T	PS
Prickly paddy melon	S	T	T	T	PS
Raspweed	-	T	T	T	PS
Rattlepod	S	T	T	T	MS
Rynchosia	-	T	T	T	MS
Sesbania	MS	T	S	T	MS
Small-flowered mallow	T	T	T	T	PS
Spineless clatrop	MS	S	S	T	S
Sowthistle	S	T	T	T	S
Sunflower	MS	T	S	T	S
Thornapples	S*	T	S	T	S
Wireweed	MS	T	T	T	S
Wild gooseberry	MS	T	S	T	S
Wild melon	S	T	S	T	S
Wild turnip	S	T	T	T	S

S Susceptible, MS Moderately susceptible, T Tolerant, PS Some activity, – Not known

*** Because of their large seed size, these weeds may germinate below the herbicide band, reducing the level of control achieved.**

**** Zoliar® is a residual herbicide and should be applied in advance of the cotton season. It requires thorough incorporation and for nutgrass control, needs to be applied in 2 or 3 consecutive seasons.**

***** Glyphosate is toxic to conventional cotton and can only be safely applied to conventional cotton post-emergence through a well constructed shielded sprayer.**

Table 35: A guide to weeds controlled by the post-emergence, over-the-top, grass herbicides.

Trade Name Herbicide Group	Falcon® 120-180 mL/ha A	Fusilade® 750 mL/ha A	Select® 250-375 mL/ha A	Sertin® 120-180 mL/ha A	Verdict® 1.0-1.5 L/ha A
GRASS WEEDS	**S Susceptible, MS Moderately susceptible**				
Annual grasses general	S	S	S	S	S
Barnyard grass	S	S	S	S	S
Johnson grass from seed	S	S	S	S	S
Liverseed grass	S	S	S	S	S
Volunteer cereals	S	S	MS	S	S

HERBICIDE RESISTANCE

Information regarding the herbicide group to which the product belongs is included on the product label. This information is an essential component of a weed management strategy that endeavours to avoid the development of herbicide resistant weeds. The herbicide groups are indicated by a lettering system, as shown in **Tables 33, 34 and 35**.

Modes of Action

There are many different modes of action of herbicides, although similar herbicides may have similar modes of action. For example, the post-emergence grass herbicides (**Table 35**) are all group A herbicides that act through inhibiting acetyl coA carboxylase, leading to membrane disruption in the plant. However, of the pre-emergent grass herbicides (**Table 33**), trifluralin and pendimethalin are both group D herbicides, that inhibit tubulin formation, effectively inhibiting plant growth, whereas metolachlor is a group K herbicide, that has multiple modes of action that inhibit plant growth and root elongation.

Development of Resistance

A herbicide will effectively control its target weeds when applied correctly. Nevertheless, within any weed population there will be weed species that are more tolerant of the herbicide, and within a species there may be individual plants that are more resistant to that herbicide than the remainder of the population.

Repeated use of a herbicide may have two effects. Firstly, the herbicide will select out the more tolerant species, probably resulting in a species shift in favour of these species. That is, the density of the more herbicide susceptible species will decline, but there will be a relative increase in the density of the herbicide tolerant species. Secondly, the herbicide may select out the more herbicide resistant individuals from within a species and the frequency of these individuals may increase within the population, leading to the development of herbicide resistance over time.

The rate at which these changes occurs depends on a number of factors, including:

- herbicide efficacy, the frequency of herbicide application, the degree of tolerance to the herbicide, the frequency of herbicide resistant individuals within the population, the relative fitness of the resistant individuals and the nature of the weed's reproductive mechanism,
- dilution of the population from external sources, and
- the use of other management tools that reduce the population of tolerant individuals.

While all herbicides have the potential to cause a species shift in the weed population, the degree of risk of selecting out a resistant weed population is greater for some herbicides than others. Within the herbicide groups, there are three broad categories of risk.

Groups A and B are in the high risk category. Repeated use of herbicides from groups A and B gives a high risk of developing herbicide resistance.

Use of herbicides in groups C through to H is assessed to have a moderate risk of developing resistance.

Herbicides in groups I through to N have a relatively low risk of selecting out herbicide resistant weeds.

These risk categories are based on the modes of action of the herbicides. Generally, Group A and B herbicides have very specific modes of herbicidal action, and affect sites in the plant that are relatively easily bypassed. The herbicides in Groups I through to N affect more general plant functions or have multiple sites of action. It is far less likely that a plant will be able to develop alternative pathways to avoid the affects of these herbicides. The classification of the herbicides into these groups has been supported by experience, where resistance to the herbicides in Groups A and B is now wide spread, over a range of herbicides and a range of weeds, whereas there are few examples of resistance to the low risk herbicides.

Nevertheless, these risks are relative. Continuous use of any herbicide will eventually lead to the development of herbicide resistance, that is, the selection from a population of a new population that is resistant to the herbicide. Once this happens, that herbicide is no longer of any use for controlling the weed.

Rotation of Herbicides

One approach to reducing the likelihood of herbicide resistance developing is to rotate herbicides (use herbicides with different modes of action, from different herbicide groups over time), so that weeds are exposed to a range of different herbicidal actions. Unfortunately, this strategy is difficult to implement in cotton, as many of the herbicides that could be readily substituted are from the same herbicide groups.

For example, as was discussed earlier, although the post-emergence grass herbicides Falcon, Fusilade, Select, Sertin and Verdict are chemically different, they are all group A herbicides with similar modes of action. In most instances, a weed that develops resistance to one of these herbicides will be cross-resistant to all of them, even though the weed may never have been exposed to the other herbicides.

Similarly, the residual, broad-leaf herbicides most commonly used with cotton production (diuron, prometryn and fluometuron) are all group C herbicides, with similar modes of action.

However, the pre-emergent grass herbicides belong to groups D (trifluralin and pendimethalin) and K (metolachlor). Use of these herbicides in rotation allows an opportunity to expose weeds to totally different herbicide groups, greatly reducing the risk of developing herbicide resistance.

Overall, the most effective approach to reducing the development of herbicide resistance and the species shift to herbicide tolerant individuals, is to ensure that herbicides are used correctly and to use an integrated approach to weed management that employs components from each of the weed management options. Special care needs to be taken when repeated use of group A or group B herbicides is anticipated.

DEVELOPING A WEED MANAGEMENT SYSTEM

Each of the weed management tools has advantages and disadvantages, and needs to be integrated with the other tools to form an effective and efficient weed management system. This weed management system must also be balanced with the needs of the other components of cotton production, such as insect management and disease control.

A weed management system must also be flexible and able to respond to the needs of each field, each season. One of the most significant factors affecting weed management is the prevailing seasonal conditions, and in particular, rainfall. A weed management system must be able to respond to this element. Rainfall affects both weed germination and herbicide efficacy. All plants need moisture to germinate and grow. Generally, weeds will germinate only after a rainfall event, such that weeds are not normally much of a problem in a dry season. However, all residual herbicides are water activated. They are not active in a dry soil, but become active only after rain. Also most of the translocated, non-residual herbicides are much more effective on plants that are not moisture stressed. Residual herbicides should work well in a wet season, when maximum weed pressure will occur, but may not work well in a relatively dry season, when light showers can stimulate weed germination, but not activate the herbicides. In this situation, non-residual herbicides and cultivation may be needed to supplement the residual herbicides

RE-CROPPING INTERVAL AFTER COTTON

Herbicides break down over time and small amounts of a herbicide can persist for weeks, months or even years after application. Some plants can be extremely sensitive to these small amounts of herbicide and these plants can be damaged by herbicide persisting for a long time after application, even though there is no other evidence that the herbicide is still persisting.

This can be the case with cotton damaged by herbicides applied to previous rotation crops or fallows, but equally may be the case with rotation crops damaged by herbicides used in the prior cotton crop.

Table 36: Minimum re-cropping interval after application in cotton (months).

Herbicide	trifluralin	pendim ethalin	metola chlor	prometryn	Fluometuron	fluometuron + prometryn	diuron	Zoliar®	Staple®*
Barley	12	6	6	12	6	6	12	12	5
Canola	0	6	6	12	6	6	12	12	-
Chickpeas	0	0	6	12	6	6	12	12	-
Cotton	0	0	0	0	0	0	S	0	0
Cowpeas	0	0	6	12	6	6	12	12	-
Faba Beans	0	0	6	12	6	6	12	12	-
Lab Lab	0	-	6	12	6	6	12	12	-
Linseed	0	-	6	12	6	6	12	12	-
Lucerne	0	6	6	12	6	6	12	12	-
Maize	12	0**	0	12	6	6	S	12	22
Millets	12	12	6	12	6	6	12	12	-
Mung Beans	0	0	6	12	6	6	12	12	11
Oats	12	12	6	12	6	6	12	12	5
Sorghum	12	12	0***	12	6	6	S	12	22
Soybeans	0	0	0	12	6	6	12	12	22
Sunflower	0	0	0	12	6	6	12	12	22
Triticale	12	6	6	12	6	6	12	12	-
Wheat	12	6	6	12	6	6	12	12	5

*** Re-cropping intervals relate to no more than a total of 120 g/ha (240 g/ha for cotton) of Staple applied in one season.**

**** Maize can be re-sown immediately after use in a failed crop provided the seed is sown below the treated band of soil.**

***** Concept® treated sorghum seed.**

S The spring following application in cotton.

– No information is available.

The problem of herbicide residues is most likely to occur with the residual herbicides, as these have the longest life in the soil, but can also occur with some contact herbicides. The minimum re-cropping intervals after the application of herbicides in cotton are presented as a guide in **Table 36** to assist in planning crop rotations.

While the nominated plant back periods can be reduced in some instances, this should only be done after seeking further advice, or on the basis of previous experience. Planting a crop too soon after a previous crop in which residual herbicides were used is likely to result in crop failure, or crop damage, that may not be apparent in initial crop establishment.

FEED BACK

While every effort has been made to ensure that the information in this section is accurate, individual growers may observe results at odds with the information. If this occurs, please contact Graham Charles on: 02 6799 1500 so that he can incorporate this information into future editions of the Weed Management section.

By Rob Eveleigh, CSD
& Dave Larsen, Cotton CRC

Management of insect pests in cotton is very intensive and calls for highly skilled management. Insecticide inputs constitute one of the major costs associated with cotton production.

An Integrated Pest Management (IPM) Approach

IPM provides a basis for establishing a whole farm approach to insect management. It is the central theme for this chapter.

IPM for cotton is a system that integrates all available, practical means of managing pest populations with the aim of reducing insecticide use while maintaining or improving profitability, yield, fibre quality and crop maturity. An operational definition of IPM developed by the FAO indicated that:

- the presence of pests does not automatically require control measures as damage may not be significant
- when pest control measures are deemed necessary, a system of non-chemical pest methodologies should be considered before a decision is taken to use pesticides
- suitable pest control strategies should be used in an integrated manner and pesticides should be used appropriately.

While integrated pest management is nothing new, it is the best strategy to adopt to reduce the overall number of pesticide applications. Essentially, pest and predator numbers are carefully monitored and when pest populations exceed threshold the most appropriate selective insecticide is used for control.This approach aims to minimise predator mortality so that the insecticide is not the only factor operating to maintain the pest numbers below threshold.

KEY POINTS:

- **Adoption of an Integrated Approach (IPM)**
- **Follow industry guidelines for Resistance Management**
- **Use a Consultant**
- **Optimise costs according to seasonal conditions**

Use a consultant

While it is not critical that new growers immediately become proficient in insect pest management, it is important they obtain the services of an experienced consultant.

Crop consultants will be able to provide detailed information on cotton production methods, and will have well developed strategies for the management of insect pests. A consultant should check the crop every 2 or 3 days to assess insect populations. When control is warranted the consultant will suggest the best insecticide to use, in consideration with the principles of IPM and the Insecticide Resistance Management Strategy guidelines. Your consultant will also be able to help you implement more strategic insect management such as use of trap crops and assess pupae destruction requirements and practices.

Growers should engage a consultant and discuss insect control strategies well before planting. Regular contact and communication during the season should inform the grower of any insect control problems and crop progress.

Most consultants provide detailed crop management services other than just those involving insect monitoring and control. These services are usually provided on a contract basis for the full season. Approximate costs range from $30 to $50 per hectare.

Growers should also discuss and budget their anticipated chemical requirements with both their consultant and their agricultural chemical supplier.

Growers who would like to do their own pest monitoring should consider doing a cotton crop checking course at a TAFE College or consider the IPM short course run by

Intervention with broad-spectrum synthetic pesticides is seen as a last resort, when pests exceed thresholds and there are no effective selective managements options available.

Australian Cotton CRC (contact your local cotton IDO or DA). However, it would be advisable to use a consultant for the first year at least.

Since insect control costs make up a large proportion of production costs growers should take an active interest in insect management decisions with their adviser.

Thresholds are important

Insect thresholds have been developed as a guide to determine the need for control. Using lower treatment thresholds than recommended in the Cotton Pest Management Guide will not necessarily increase yields. However, lower thresholds usually increase the number of sprays, insect control costs can escalate, and insect resistance will be exacerbated. Standard thresholds are given in the table below. Growers are also encouraged to use the IPM guidelines provided in the Cotton Pest Management Guide (available from your local DPI/NSW Agriculture office) or in EntoPAK (available from the Aust Cotton CRC's Technology Resource Centre). The guidelines are also available from the Cotton CRC website www.cotton.crc.org.au/Publicat/Pest. These guidelines suggest using dynamic thresholds that vary with crop progress.

Research on heliothis thresholds has been ongoing for many years but only a few trials have been done under dryland conditions. Research by Dallas Gibb at Moree and by CSIRO at Edgeroi indicate that insect thresholds recommended for irrigated crops are quite conservative when used for dryland crops. In general, higher heliothis larvae numbers, particularly during the pre-flowering stage of growth can be tolerated under dryland conditions without reducing yields.

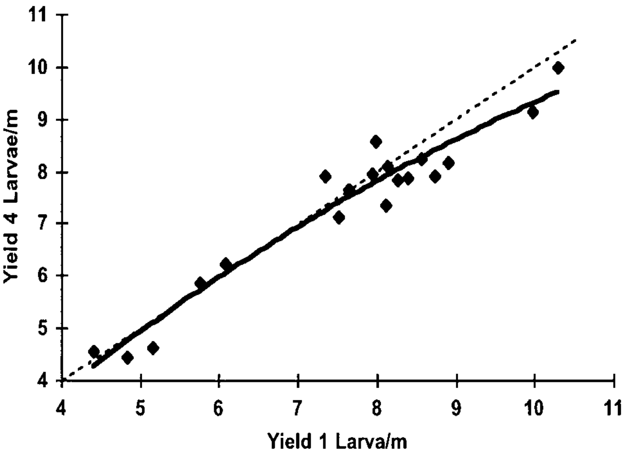
These thresholds should be used as a guide only. Thresholds may need to be varied up or down depending on damage levels and the effects of other pests such as green mirids (**Table 37**).

Figure 19 Shows there is no difference in yield between crops managed with 1 larva/m and 4 larvae/m at normal dryland yield levels. (Dallas Gibb pers comm).

Table 37: Standard Heliothis Thresholds (No./m).

	Phase I	Phase II	Phase III
Brown eggs	-	5	-
Very small & small	2	3	2
Medium & large	1	0.5	1
Total Larva	2	3	2

Figure 19: Yield comparisons for crop managed using pre-flowering threshold of 1Lava versus 4 Lavae/m.



Insects cannot tell the difference between irrigated crops and dryland crops when moisture stress is not present, but in many seasons moisture stress will make the dryland crop less attractive to insects. The lower humidity of dryland crops also reduces the survival of many insects.

In most seasons water stress will limit the yield potential of dryland cotton. Plant compensation for the loss of early squares is considered to occur at yields less than 5 to 7.5 bales/ha (depending on variety). Few dryland crops exceed these yield levels so compensation for some square loss is likely. With high levels of heliothis damage maturity can be delayed. For example up to 7 days delay in maturity has been recorded when 60 squares per metre were removed (this equals about 6 heliothis larvae per metre). But only slight differences in maturity are likely when comparing normal thresholds with low thresholds.

Dryland principles

The insect management strategy must be closely related to soil moisture status, insect pressure and realistic yield expectations. Generally aim to protect those fruit for which there is adequate moisture to produce mature bolls. Cotton has an indeterminate fruiting habit that enables it to keep producing fruit until some stress stops it. At yields below 5 bales/ha most cotton varieties can compensate for some insect damage. Varieties such as Siokra 1-4 can compensate for early insect damage very well and all "okra" leaf varieties have some tolerance to heliothis and mites.

Cotton Insecticides

Insecticides will be the major method of insect control for cotton. Insecticides are scheduled according to toxicity to humans, and growers should follow the handling and mixing instructions carefully to avoid the risk of poisoning.

There are a large number and type of insecticides registered and used to control pests in cotton. The Cotton Pest Management Guide, available from NSW Agriculture and QDPI offices, is an excellent source of information on pesticide recommendations.

A strategy to minimise the development of resistance to insecticides, miticides and transgenic cotton in northern NSW and Queensland is prepared each season and should be closely followed. Details of the current strategy are available from NSW Agriculture and QDPI offices. It is reviewed before the start of each season, and growers will need to keep themselves informed of any changes that occur.

While 5 to 10 insecticide sprays can normally be required during the course of the growing season for conventional varieties, under very high pest pressure 15 or more insecticide sprays may be required. Ingard® varieties will require approximately half the number of sprays for heliothis.

All growers also have the option of using CottonLOGIC to assist with their pest management decision making and record keeping.

Insecticides in IPM

Insecticides have been ranked with a "Beneficial Disruption Index" (BDI) according to their impact on beneficial insects. This can help to optimise their use in an IPM strategy.

Insecticides range from 'soft' (those that control target pests with little negative affect on beneficial insects) through to 'hard' (those that control the target pest and have a significant affect on beneficial insects).

Some insecticides are moderate in their affect on beneficial insects because they may have little negative affect on some beneficials but a greater affect on others.

For this reason it is important to consider the selectivity of the insecticide when deciding what pesticide to use to control the pest.

for more detailed information refer to IPM Guidelines support Document No.1, in EntoPAK. Available from the Cotton CRC Technology Resource Centre. Contact Dave Larsen 0267 991534. It is also available on the following website: http://stage-mv / Assets / PDFFiles / IPMGL99 / IPMSD01.pdf

BIOLOGICAL INSECTICIDES

A number of products containing Bacillus thuringiensis (termed Bts) as well as Heliothis viruses are registered for use in cotton. These products basically consist of solutions or powders derived from bacterial cultures or in the case of Heliothis viruses - Gemstar and Vivus, a suspension of virus particles. When used as directed, these products will selectively control plant feeding caterpillars such as heliothis larvae. Because of their unique properties they have an important role in the Integrated Pest Management programs developed for the Australian cotton industry.

Bts and Heliothis viruses have no effect on beneficial species such as predators and parasites. Therefore when used during early season (Stage 1) they can allow numbers of beneficials to build up at similar rates to unsprayed cotton.

Bts and Heliothis viruses used in combination with other insecticides later in the season e.g. thiodicarb, endosulfan and the synthetic pyrethroids (SPs), can help reduce the selection of pests with resistance to those chemicals.

Bts and Heliothis viruses are particularly good products for use near waterways, houses, or other environmentally sensitive areas. They have no contact activity and are active only after the caterpillar ingests them. With Bts the larvae stop feeding within minutes of ingesting the treated plant material, and cause no further damage to the plant. Bts cause the stomach wall of the larvae to breakdown causing death due to starvation, septicemia, and toxic shock. Sick and dying larvae can usually be found in the treated crop for 2-4 days after spraying. Death can be quicker under dry, hot conditions as the larvae desiccate at a faster rate.

Heliothis viruses are more slow acting than Bts or many conventional pesticides. They infect the larva and rapidly multiply within it. The dead larva can sometimes transfer the disease to other larvae thus perpetuating the infection in the field particularly when conditions are favourable.

Performance of Biological Sprays

Timing. Biologicals are most effective on hatchlings and very small larvae. Sprays are ideally timed to coincide with the brown egg stage of development or at hatching larvae.

Crop Coverage. Thorough coverage of the main larval feeding sites is essential as the material needs to be ingested.

Environmental Conditions. If possible, apply when larvae are actively feeding, and when there is low exposure to UV light - preferably early evening or night. Recent research on the application of Gemstar did not find significant difference in performance when applied in the morning although there was a trend toward better performance when applied in the evening. Addition of milk powder improved activity in some situations. Additional wetting agents or stickers may be required to improve product performance under rainy conditions. **Read the label for directions.**

Rate. Best results are obtained at the higher registered rate, particularly if the biological is to be used alone.

Growers must be aware that use of Bt sprays is not permitted on conventional sprayed cotton that is designated as an Ingard® refuge. However Heliothis viruses can be used at any time on sprayed Ingard® refuges.

Ingard® For Dryland

Ingard® is a plant produced protein insecticide that is purchased on a green hectare basis. A range of dryland adapted cotton varieties that produce the Ingard® insecticidal protein are available. Trials and commercial areas of Ingard® were first grown dryland in the 1996-97 season and results were generally good. Expression of the Ingard® protein does not appear to be diminished by moderate moisture stress however the economics of using Ingard® in a rain fed environment need to be carefully assessed.

Pricing based on green hectares has made Ingard® a more attractive option for growers using skip row configurations.

The high early fruit retention sometimes provided by Ingard® can cause crops to cut out more quickly. This can mean a yield disadvantage if rain patterns suit later maturing crops.

Ingard® crops make it easier for growers to adopt an integrated approach to pest management.

SECONDARY PEST MANAGEMENT

Many insect pests other than heliothis infest cotton and have the potential to reduce yield and quality. Mites, aphids, thrips, mirids and tipworm are some of the more common secondary pests.

Mites are seldom a problem in dryland crops but should be carefully monitored as they can reduce yield and quality significantly if they establish a significant population before February.

Aphids are often found in the crop from emergence onwards. They can develop very high populations but are generally easy to control. Resistant strains of aphid are now present so care should be exercised where a spray failure has been detected. Aphids have also been linked to a new disease of - Cotton Bunchy Top. Early heavy infestations of aphids should be controlled if bunchy top is considered to be present. Normally cotton can tolerate quite high numbers but once cotton bolls begin to open, aphids should be managed so that there is no risk of honey dew production. Honeydew contaminated lint has large price discounts and its presence could ruin Australia's reputation as a supplier of high quality cotton.

Thrips are a pest of seedling cotton but only require treatment if damage thresholds are reached. While thrips can damage early leaf growth and make a crop look unattractive, research continues to show that early leaf damage will not affect crop yield or maturity. An exception to this may be in cooler season areas where the combination of leaf damage and cool nights may restrict plant growth. Commonly used seed treatments give good short term control of thrips. (Thrips are excellent mite predators and early flaring of mite numbers is usually associated with situations where the use of certain pesticides has eliminated thrip populations)

Mirids can be a problem in dryland cotton. They are often difficult to detect in the field, and monitoring square retention or the rate of square number increase is an important consideration when deciding if control is necessary. Applications of organophosphates and pyrethroids have been regarded as the most effective control methods but can be very disruptive to beneficials. New products such as Regent® can be used to reduce the impact on beneficials. Endosulfan can also been used to suppress light - moderate mirid populations.

Tip worms are usually present in low numbers every year and are often mistaken for heliothis larvae. Tip worms sometimes occur in very large numbers following cool wet winters and have the potential to cause severe damage to the cotton growing tip and squares. Large numbers of the pest's distinctive eggs can be used to alert growers before the larva cause excessive damage. Once the tip worm larvae become entrenched in plant tissue chemical control is usually ineffective. Ingard® cotton provides very effective control of tip worms.

For current insecticide recommendations please refer to the *Cotton Pest Management Guide.*

MANAGING INSECTICIDE RESISTANCE IN HELIOTHIS

Key Strategy Guidelines

1. Cultivate cotton and alternative crop residues as soon as possible after harvest to destroy over wintering H. armigera pupae. Cultivation must be completed before the end of August.

2. Use recommended larval thresholds to minimise pesticide use and reduce resistance selection.
Refer to the current *Pest Management Guide for Cotton*. Monitor first position fruit retention. If egg numbers will produce a larval population greater than the recommended threshold, target sprays on newly hatching larvae.

3. Monitor 1st position fruit retention pre-flowering. Aim to retain around 60%.

4. Avoid using broad spectrum sprays - such as organophosphates or pyrethroids early in the season. They reduce the numbers of beneficial insects and increase the chance of mite and aphid outbreaks.

5. Monitor mite populations regularly after seedlings emerge. If established mite populations are present (>5 to 10% of plants infested) avoid using broad spectrum insecticides to control other pests (see 4). Instead use selective compounds or compounds that also control or suppress mites, either alone or in mixtures as required.

6. Avoid continuous sprays of any one chemical group, including Bt products. (Rotate between chemical groups where possible). Do not exceed the maximum acceptable use limits indicated on the Cotton Resistance Management Strategy chart.

7. Do not respray an apparent failure with a product of the same group - unless the failure is clearly due to factors such as poor application or timing, etc.

8. Control weeds on farm to minimise hosts for mites and other pests, particularly in the winter-spring period.

9. Comply with any use restrictions placed on insecticides used on crops other than cotton for the purposes of managing resistance.

For future reference go to the Cotton CRC website: *www.cotton.crc.org.au*, then click onto Publications then click onto Insect Resistance Management Strategy, or refer to the current *Pest Management Guide for Cotton*.

To be on the Cotton Industry mailing list please contact Dave Larsen 02 6799 1500.

CottonLOGIC

by Dave Larsen

CottonLogic, the latest management tool available to cotton growers to help them with their cotton farming decisions, was developed by a team of researchers at CSIRO Plant Industry.

It is distributed for free by the Australian Cotton Cooperative Research Centre.

Information on insect pressures, crop inputs, pesticide applications, field operations and much more can be stored and easily accessed. This information can then be used to make decisions to improve cotton crop production and sustainability.

It incorporates:

- EntomoLOGIC- A pest management decision support system. As well as data entry, storage and reporting it contains the following insect models:
  - Helicoverpa life cycles - predicts pest pressure for the next 3 days
  - Mite models - predicting mite pressure, yield loss and predicted date over threshold

  These models provide information to the user for a more informed decision and better pest management.

- NutriLOGIC for irrigated crops - Analyses soil and petiole nitrate tests and gives nitrogen recommendations to maximise yield. Use on irrigated crops only
- Support for Rotation and Refuge crops
- User-Definable INGARD® Thresholds
- Weather Data Entry for Operations
- Forecast Temperature Data Entry for more accurate Helicoverpa pressure prediction
- A comprehensive range of cotton pest and beneficial insect pictures and information
- Helicoverpa diapause model, predicting the number of pupae entering diapause and their expected re-emergence dates

Why use CottonLOGIC?

Supports the 3 industry sampling methods (numbers per metre, numbers per plant and presence/absence sampling methods).

- Supports INGARD® thresholds
- Supports plant mapping techniques.
- The insect thresholds for the various cotton pests are user definable to suit their own management strategy.
- CottonLOGlC is also a valuable record keeping system for all agronomic data. Information on insect pressures, crop inputs, pesticide applications, field operations and much more can be stored and easily accessed.
- CottonLOGlC allows growers to check the status of a whole farm to determine where pests are most prevalent and how they are being controlled.
- CottonLOGIC is a computer software package that will help with farming decisions, in particular for insect pests.
- CottonLOGIC enables the user to browse a series of insect pictures at various stages of their life cycle.

As insecticide resistance increases, pest management decisions are becoming increasingly complex and costly.

As well as providing valuable information for decision-making, CottonLOGIC can store information about insect checks, sprays, irrigations, crop planting and development rates, fruit counts, yields, plant maps and much more. For example, by keeping records of sprays and insect pressures, growers and their advisers can review the performance of pesticide applications.

Consultants can provide additional information to growers in the form of end-of season or progress reports. Daily summary reports indicate the status of a whole farm allowing growers to determine where pests are most prevalent and how they are being controlled. Spray records can be used to ensure that resistance management guidelines are followed to minimise pesticide resistance.

CottonLOGIC software for insect management is now available for the Palm Operating System for use on handheld devices. This system has been designed to help in-field decisions and to streamline data entry.

Maximising Yields

CottonLOGIC has been used over a number of seasons in large scale trials on irrigated and dryland cotton farms. Excellent results have been obtained using CottonLOGIC's standard thresholds and both conventional and selective insecticides. This work has also identified ways to reduce dependence on pesticides by maximising the benefit of predatory insects.

By using the standard thresholds growers can minimise sprays while maintaining yield and earliness.

The advantage of using thresholds is that sprays can be scheduled according to the insect pressure - a spray is recommended whenever insects are over the threshold but can be delayed under conditions of low pest attack.

Protecting Dryland Yields

Much debate has surrounded insect management on rain-grown cotton. Excellent yields have been achieved in rain-grown crops using CottonLOGIC with standard thresholds. In comparative trials, cotton managed using CottonLOGIC achieved the same yields as commercial plots.

Pesticide sprays are the major variable cost in dryland cotton production. Therefore pest management decisions can have a higher impact on farm profits than in irrigated cotton.

CottonLOGIC PC System Requirements:

- Windows 95, 98, 2000, NT, ME/XP.

(CottonLOGIC has been run on Macintosh PowerPC in conjunction with soft windows)

- A Pentium or 486 with at least 32MB RAM
- 256 colour screen for insect pictures
- 17Mb of disk space for complete installation

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By Steve Allen, CSD/CSIRO
& David Nehl, NSW Agriculture

Diseases are not usually a major problem in dryland cotton. Brief information is given in this section, but the Agfact entitled *Diseases and Weeds of Cotton* – available from NSW Agriculture and the Australian Cotton CRC's *Integrated Disease Management Guidelines* are more detailed references.

Seedling diseases

Seed rot and pre- and post-emergent damping off can be caused by several fungi, including *Pythium* and *Rhizoctonia*, which are common soil inhabitants. Thin or patchy plant stands and/or weakened root systems may result. Seedling diseases are most likely when cool, wet weather occurs soon after planting and when there is a carryover of legume residues from a previous crop.

To minimise losses:

- Prepare the seed-bed early so that plant residues have ample time to decompose.
- Avoid planting too early in the season when soil temperatures are too low.
- Do not plant seed deeper than necessary,
- Use seed treatments which control both Pythium and Rhizoctonia.

Black Root Rot

The fungus causing this disease (Thielaviopsis basicola) is favoured by relatively cool soil temperatures and is therefore most active early in the season. Affected seedlings are stunted and grow very slowly as a result of extensive blackening and damage to the root system. Where this disease is present it is important to avoid early planting and the use of legumes in the rotation. Many legume crops are also hosts of the fungus. Black root rot is widespread in irrigated cotton and is easily spread in infested soil adhering to machinery or vehicles.

Vascular Wilts

Verticillium dahliae and *Fusarium oxysporum f.sp. vasinfectum* cause Verticillium wilt and Fusarium wilt of cotton. These fungi infect plants via the roots and then invade the water conducting (vascular) tissue, blocking water uptake and causing yellowing, leaf mottle and sometimes wilting and death of plants. Brown discolouration of the root and stem vascular tissues becomes apparent.

KEY POINTS:

- **Under most dryland conditions, diseases are usually not a problem.**

Verticillium wilt is favoured by cool air and soil temperatures, excessive soil moisture and higher soil nitrogen levels. Verticillium wilt is common in most cotton growing areas and the causal organism has a wide host range that includes many common weeds. Varieties with some resistance to the disease are available and should be used if the disease is present.

Fusarium wilt has emerged as a major threat to irrigated cotton production in Australia. Evidence suggests that the disease has been dispersed with soil and crop residues attached to vehicles and machinery and in flood waters. The disease has been observed in a small number of dryland crops, especially where those fields have been inundated previously with contaminated flood water. Varieties with some resistance to this disease are available.

Leaf Spots

Leaf spots generally occur after periods of wet weather and are usually most severe on the lower leaves of the plant.

Alternaria leaf spot is characterised by brown or grey, dry spots which are most common on either very young seedlings or on plants approaching maturity.

Bacterial blight features dark green, angular, water-soaked spots that are particularly obvious on the lower surface of the leaf and may occur throughout the season.

Both of these leaf spot pathogens can also infect young developing bolls. The fungi that cause Alternaria leaf spot (*Alternaria macrospora* and *A. alternata*) survive from season to season on crop residues and on some weed hosts.

Crops that are subject to stress late in the season tend to be more susceptible. Some cultivars are more resistant than others.

Most commercial cultivars grown in Australia are completely resistant to bacterial blight. The 'Pima' cultivars are very susceptible. The bacterium which causes the disease (*Xanthomonas campestris pv. malvacearum*) survives within seed and on infested cotton crop residue.

Boll rots

Boll rots are usually only a problem in rank, irrigated crops where the humidity within the canopy remains high. An exception is **Phytophthora** boll rot caused by *Phytophthora parasitica*. This pathogen is able to infect mature bolls when soil containing the fungal spores is splashed up onto low bolls. Infected bolls quickly become dark brown to black and open prematurely. The lint does not fluff out and the locks frequently fall out of the boll and onto the ground. The disease is most severe when heavy rain occurs late in the season as the lower bolls are just about to open.

Quarantine & Clean-downs are Important!

Many cotton diseases that occur overseas are not present in Australia and it is important that they are never introduced. Similarly, there are cotton diseases that occur in some areas of Australia that are not found in other areas. Most of these diseases can be carried in crop residues and soil attached to vehicles and machinery.

It is essential that all those who move around the cotton growing areas clean down machinery and vehicles between farms.

Prevention is better than Cure!

SPRAYING AGRICULTURAL CHEMICALS

By Simon White & Peter Hughes, QDPI

To maximise spraying efficiency, pesticides must be applied at the minimum pesticide rate which will produce effective pest management without wastage through off target effects such as run-off or drift.

For this to occur, a sprayer must be capable of:

- Producing sufficient droplets of the correct size.
- Depositing these droplets in sufficient numbers evenly over the target
- Minimising effects off target.

Crops, pastures, people, stock and water supplies can all be affected by spraydrift. The resulting pollution, crop damage and the potential health hazards are something that is no longer environmentally acceptable.

APPLICATION BASICS

Droplet size

Droplet size depends on the type of equipment used and how it is set up.

Nozzles are classified by the British Crop Protection Council (BCPC) according to the type of droplet spectrum they produce. These classifications are included in most nozzle catalogues and are a useful guide for assessing the drift potential and suitability of a nozzle for a given spray job.

BCPC Category		**Approximate VMD* Range**
VF	Very Fine	< 150 µm**
F	Fine	150 – 250 µm
M	Medium	250 – 350 µm
C	Coarse	350 – 450 µm
VC	Very Coarse	450 – 550 µm
EC	Extremely Coarse	> 550 µm

µm = microns

KEY POINTS:

- **Set up the sprayer for good coverage**
- **Match the droplet size (or spray quality) and spray volume to the product requirements**
- **Avoid still conditions when spraying**
- **Avoid high temperatures when spraying**
- **Fan nozzles outperform hollow cones for applying insecticides**

BCPC Spray Classification

The BCPC classification system uses a set of reference nozzles to compare the spray quality of a manufacturer's nozzles. From the reference nozzles a series of curves are drawn up, if the spray quality of the manufacturers nozzle falls within the boundaries of two curves, that is the spray classification it is given. (VMD = Volume Median Diameter).

Droplet Sizes for Different Targets

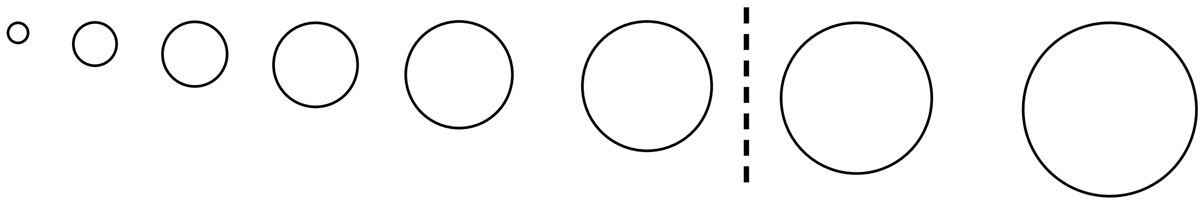
Regardless of the target our aim should be to get the best coverage possible of that target, while minimising the off-target losses as much as we practically can.

Our understanding of the droplet sizes required for different targets is slowly improving. Recommendations for the application of different product types onto different targets are emerging all the time so it is important to monitor this progress closely.

Where present we must follow label instructions as to the application of particular product types. Where this information is not provided we can apply the following 'best bet' principles.

The size of the droplet will determine its characteristics and how it will behave once released from the sprayer (**Table 1**).

Figure 20: Volume Median Diameter (VMD*) is the droplet size at which 50% of the spray volume exists in droplets larger than this size and 50% of the volume exists in droplets smaller than this size.

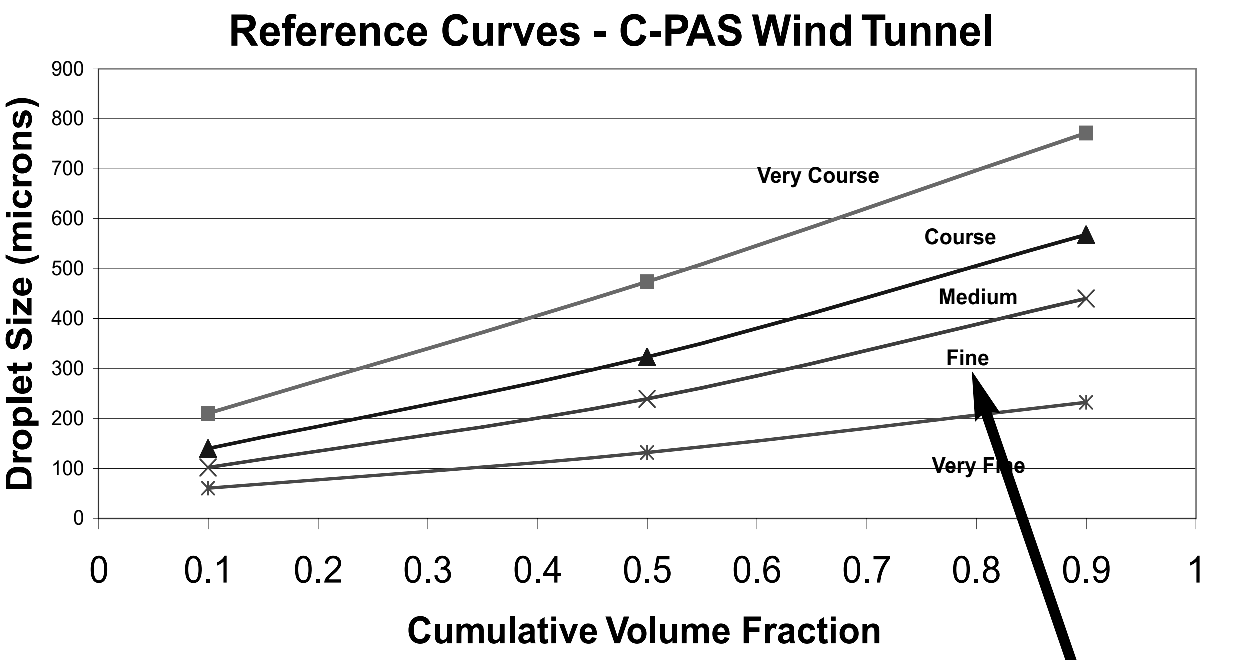


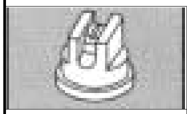
VMD

Note: The VMD is NOT the average, there will always be a greater number of small droplets than large ones.

Microns (µm) ** is the abbreviation for micrometers. There are 1000 microns in 1 millimetre.**

Figure 21 & 22: Example of BCPC Reference Chart and how the reference curves are used for nozzle droplet classifications tables.



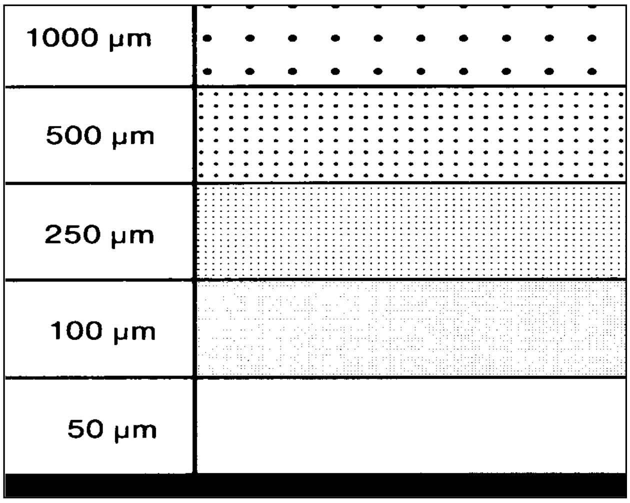
DG TeeJet® (DG)					
	bar				
	2	2.5	3	3.5	4
DG80015	M	M	M	F	F
DG8002	C	M	M	M	M
DG8003	C	C	M	M	M
DG8004	C	C	C	C	M
DG8005	C	C	C	C	C
DG110015	M	F	F	F	F
DG11002	M	M	M	M	M
DG11003	C	M	M	M	M
DG11004	C	C	M	M	M
DG11005	C	C	C	M	M

A nozzle that has been assigned a FINE (F) spray quality will produce droplet sizes within a particular range.

Spray quality:
C -Course
M -Medium
F -Fine

	Spray Classification	**Comment**
Insecticides		
Contact	Fine – Medium	If using medium stay at the finer end.
Systemic	Fine – Medium	If using medium stay at the finer end.
Fungicides		
Protectant	Very Fine	Be aware of droplet spectrum and evaporation.
Curative	Very Fine-Medium	If using medium stay at the finer end.
Herbicides		
Soil Applied	Coarse	Use appropriate water volumes to ensure coverage.
Contact	Medium	Use at the coarse end & monitor conditions.
Systemic	Medium-Coarse	Medium preferred where conditions allow.

Figure 23: Comparative Droplet Sizes (Source Agrevo & Spraying Systems)



Drift Potential

Very fine and fine droplets pose the highest risk of spray drift. Under normal spray conditions coarse droplets will only be moved sideways by the prevailing wind but will not move large distances.

Canopy penetration

Coverage throughout the canopy and underneath leaves is best achieved by fine droplets. Large droplets move downwards due to gravity and will generally be deposited on horizontal surfaces and the upper most outside parts of the plant canopy.

Evaporation risk

Fine droplets will evaporate rapidly under hot dry conditions.

Table 38: Droplet characteristics.

	Droplet size groups (BCPC)		
	V. fine	Fine -Med.	Coarse+
Size	<150 µm	150 - 350 µm	> 350 µm
Canopy penetration	High	Medium	Low
Evaporation risk	High	Medium	Low
Drift potential	High	Medium	Low
Coverage / volume	High	Medium	Low
Inertia /gravity effect	Low	Medium	High
Uses	Insecticides. Fungicides.	Insecticides. Contact herbicides.	Insecticides. Soil applied pesticides.

KEY:

- Best option for most situations
- Suitable option caution recommended
- This option not recommended

Table 39: Droplet survival times and distance fallen by a spherical water droplet under different Δt's before the droplets disappear. (Δt is the difference between the wet and dry bulb temperatures).

Droplet diameter (µm)	ΔT (°C) Difference between wet and dry bulb temperatures			
	6	8	10	12
	Droplet survival times (seconds)			
10	0.2	0.2	0.1	0.1
20	0.8	0.6	0.5	0.4
50	5.2	3.9	3	3
100	21	16	13	10
200	83	63	50	42
500	333	250	200	467

Droplet diameter (µm)	ΔT (°C) Difference between wet and dry bulb temperatures			
	6	8	10	12
	Distance fallen before a droplet disappears (cm)			
10	0.03	0.02	0.02	0.02
20	0.5	0.4	0.3	0.3
50	20	15	12	10
100	313	234	188	156
200	5 000	3 750	3 000	2 500
500	80 000	60 000	48 000	40 000

Coverage /volume

As the droplet size decreases many more droplets are produced from the same volume of spray. There is an eight fold relationship between droplet size and number. As you can see in **Table 40**, you need eight times the number of 200µm droplets to have the same volume of 400µm droplets.

When using large droplets the spray volume must be increased to maintain acceptable coverage/droplet number.

The droplet density required may vary with the type of product to be used. Traditionally 20 to 30 droplets/cm^2 was considered sufficient for most products. However many products now specify on the label a droplet density of between 60 – 70 droplets/cm^2. It is also likely that with the new ingestive active products becoming available, greater coverage will be required to ensure adequate levels of control.

Inertia/gravity effect

The higher the inertia of a droplet the more likely the droplet will be deposited on the target. Large droplets have inertia due their size. The movement of large droplets is predominantly determined by gravity. Most will deposit on flat surfaces, on the ground or the outside of the plant canopy.

Small droplets have very low inertia due to their small size. To increase inertia of a droplet, increase its travel speed (air assisted sprayers use this principle). If the speed is too high too much spray will be deposited on the outside of the plant canopy, or be wasted due to droplet bounce.

Table 40: Comparative droplet numbers for different droplet size.

Size	No. of droplets/mL of spray
100µm	1909559
200µm	238732
400µm	29841

Table 41: Droplet densities for the pesticides.

Product	No. of droplets/cm2
Insecticide:	60-100
Herbicide:	
pre-emergent	20-30
post-emergent	30-40
Fungicides:	
Contact	50-70
Systemic	20-30

Application efficiency

There are many methods of assessing the efficiency of pesticide spray application. Biological assessment for insecticide application, quickly answers the question "did the spray work or not?" By measuring droplet deposition on the target surface and combining this with a biological assessment, it is possible to quickly isolate problems into either the chemical or its application. Droplet deposition can be measured using fluorescent dye tracers or with oil or water sensitive papers.

NOZZLE IDENTIFICATION

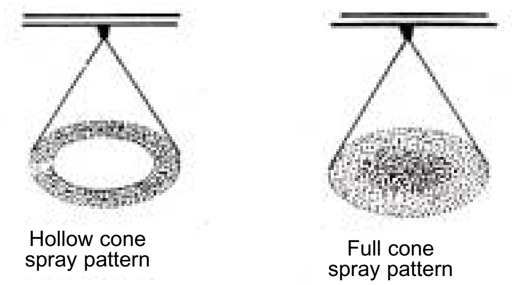
The nozzle is the most important but often most neglected and least understood component of the sprayer.

The type of nozzle selected determines the droplet spectrum produced, the volume of spray applied, the required boom height and the life of the nozzle. Each nozzle is normally identified by letters and numbers on the body of the nozzle plus a colour coding system which designates performance characteristics.

Nozzle Types

The most commonly used nozzle types in broadacre farming are cones and flat fans.

Cone Nozzles



Hollow cone nozzles are used mainly for insecticide and fungicide application. They can be operated as a broadacre spray or as a row crop spray using 1-5 nozzles for each row.

The hollow cone pattern is produced by the swirling action within the nozzle. The liquid is forced into a swirl chamber through slots in a swirl plate. The liquid then passes through the orifice and forms a thin sheet in the hollow cone pattern. Droplet size is smaller due to the higher energy in the liquid sheet.

Full or solid cone nozzles give a coverage across the full area of the cone. They are used for soil applied herbicides and situations where high volumes are required.

Characteristics of cone nozzles:

To decrease spray angle: decrease orifice size
decrease swirl slots
decrease swirl chamber depth
increase pressure

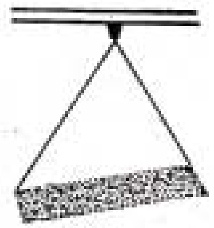
To decrease droplet size: decrease orifice size
decrease swirl slots
decrease swirl chamber depth
increase pressure

Fan Nozzles

With fan nozzles liquid is forced into the nozzle chamber and through a rectangular or lens shaped orifice.

There are two main types of fan nozzle:

Even Fan Nozzle:



Even fan
spray pattern

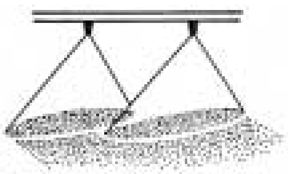
The even fan produces an even distribution pattern across the full nozzle swath width.

They are used for band application of herbicides. The nozzle fan angle and operation height determines the width of the band.

All brands carry the letter E on the face of the nozzle so as they can be easily identified.

Flat or Taper Fan:

Taper fan
spray pattern



Taper fan showing
nozzle arrangement

Flat or tapered fan nozzles are the most common type of nozzles used in broadacre situations and increasingly for insecticide application in cotton. They are characterised by an individual elliptical spray pattern. Uniform distribution is achieved by a 30% overlap of the tapered edges of the spray pattern.

Striping due to boom height variation can be minimised by doubling the boom height to achieve double coverage.

At very lower pressures the variation of spray under the boom increases due to the decrease in the fan angle of the nozzle.

Table 42: Flat fan nozzle heights (above the target) at 50cm nozzle spacing.

Fan Angle	Single Coverage	Double Coverage
80°	46cm	92cm
110°	25cm	50cm

Flood Nozzles

Flood nozzles are high volume, low pressure, wide angled fan nozzles. These nozzles are used for pre-plant incorporated and surface applied herbicides. Because this nozzle has a large orifice it may be used in situations where clogging is a problem such as liquid fertiliser application.

Low Drift (Drift Guard) Nozzles:

The low drift nozzles operate at conventional pressure but have a different design. They have a pre-orifice plate above the nozzle chamber which cause the nozzle to produce more large droplets and less of the small droplets that may drift.

Remember: When large droplets are used to reduce drift - higher spray volumes are needed to maintain acceptable coverage.

Air Induction Nozzles

These nozzles use a combination of hydraulic nozzle and air inclusion to produce droplets. The two main types of nozzle are those that use venturi air aspiration (eg TeeJet® AI, Hardi® Injet, Turbodrop®) and those that use an air compressor for the air aspiration (eg TeeJet® AirJet and the Airtec®). The droplets produced by the nozzles are a mixture of air and water. This air inclusion depends on the properties of the pesticide formulation and any additives included in the mix.

Cones vs Fans

There are a number of situations where a choice is made between a hollow cone and flat fan. The main differences between the two nozzles are:

¥ Cones produce more droplets less than 100µm (drift & evaporation prone)

¥ Droplets from the cone float more because they have a lower velocity when exiting the nozzle

¥ Cones have a spray angle of 80°, whereas flat fans are available in 110°.

Figure 24: Single Coverage Spray Pattern.

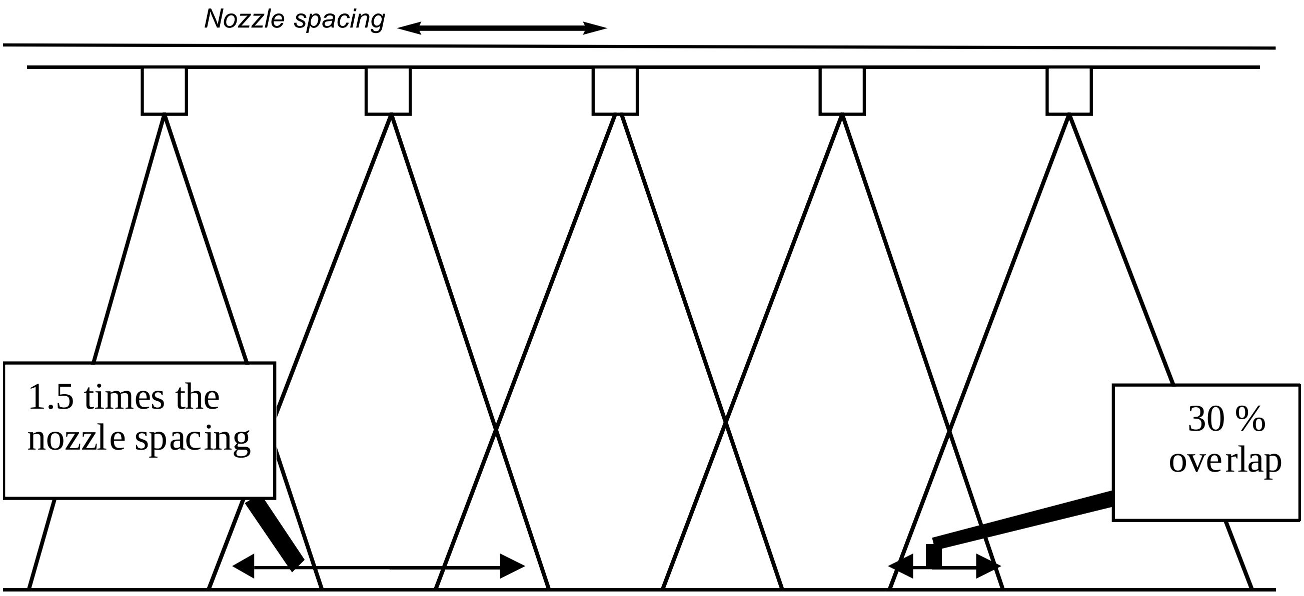
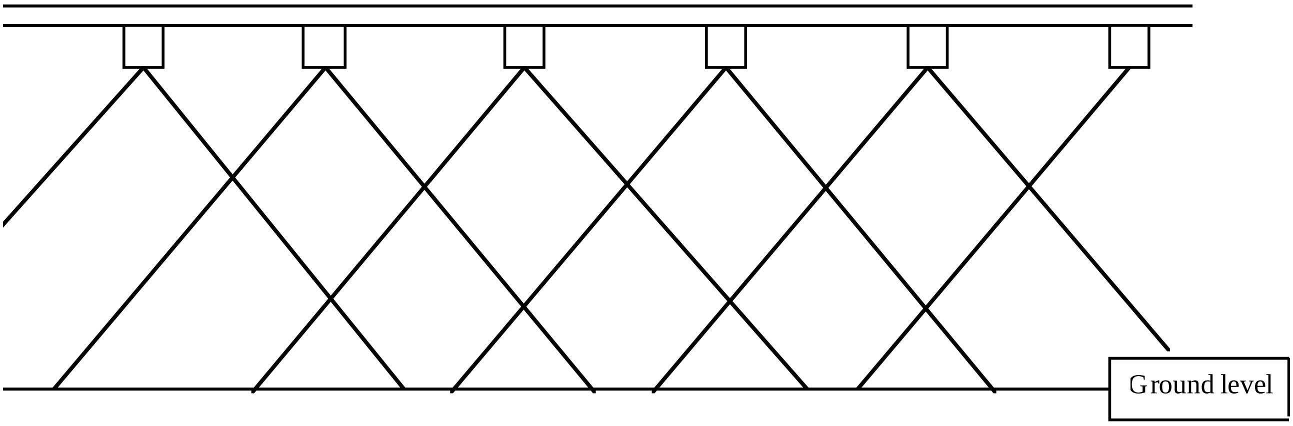


Figure 25: Double Coverage Spray Pattern.



Other nozzles are available for specific applications such as off centre depositions, twin outlets, deflector, agitation, boom ends and rinsing. Check identification against manufacturers specifications.

MATERIAL OF CONSTRUCTION

Nozzles are made from a wide range of materials and the material of construction is normally depicted by letters and colours.

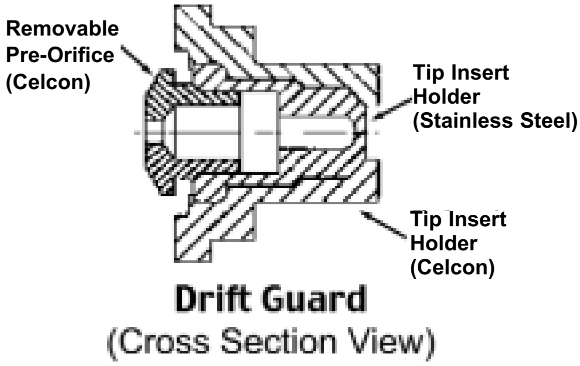
For example:

Spraying systems	**VK - ceramic**
	VH - hardened stainless steel
	VS - stainless steel
	VP - polymer
	VB - brass

Ceramic nozzles are best value for money. Although they cost more initially, they are the most resistant to wear.

ALL NOZZLES WEAR AND NEED TO BE REPLACED ONCE THEIR FLOW RATE EXCEEEDS 10% MORE THAN MANUFACTURERS SPECIFICATIONS.

Figure 26: Teejet - Drift guard Nozzle (Source: Teejet®)



COLOUR CODING

"OLD" MANUFACTURER IDENTIFICATION SYSTEM

The old systems used numbers, letters and colours combined to give a full identification for each manufacturers product. Confusion arose because each manufacturer combined identifying characters in different combinations. If in doubt consult manufactures catalogues/ literature.

"NEW" ISO STANDARD COLOUR CODING FOR FLOWRATES.

A recent innovation for coding of nozzles is the ISO standards for colour coding and flowrates for nozzle.

Manufacturers using ISO standards all use the same colour codes for nozzles with the same flowrates. So a Hardi 110 - 02 fan (yellow) can be replaced with a TeeJet 110 - 02 fan, which also is yellow, or a Yellow Lurmark 110 fan.

ISO coding allows easy identification of flow rate. Most companies are now depicting their nozzles flow rate through a numerical system as well as a colour coding system. Whilst each number and colour should be checked against the manufacturers specification, with USA designed nozzles the number represented is normally 10% of the flow rate in US gallons/min (TeeJet 02, Delevan 2, Lurmark 02 = 0.2 US gallons/minute at 40psi).

WATER QUALITY

The quality of the water used can adversely affect a herbicide's performance. Ideally water should be clear, colourless, odourless and neutral in pH. When available, rain water is the best bet. If water contains excessive solids obvious problems such as nozzle blockages will occur. Less obvious will be the binding of the chemical to the suspended materials and subsequent loss in its effectiveness. The effectiveness of some chemicals can be drastically reduced by suspended clay particles. As well, solids accelerate nozzle wear.

IF A COIN CAN NOT BE SEEN IN THE BOTTOM OF A BUCKET OF WATER IT IS TOO DIRTY TO USE FOR SPRAYING.

Water which is either acid or alkaline in pH may break down or hydrolyse specific chemicals. If the water is known to be alkaline, spraying should commence immediately after mixing. Water high in calcium or magnesium salts (hard water) may also cause problems with mixing as the stability of suspensions and emulsions is reduced.

A quick guide to the suitability of water for spray applications can be obtained using the following procedure:

1. Make up 500mL of correctly diluted spray in a clear glass sealed container according to the manufacturer's instructions.
2. Mix thoroughly.
3. Allow to stand for 30 minutes. If, after this time, creaming, sedimentation or separation into layers occurs, the water may be unsuitable for mixing sprays. If suspected of being unsuitable, a sample of this water should be chemically analysed for salt and hardness levels.

Different brands of the same chemical may react differently because of different additives in each formulation.

If poor quality water has to be used, spray immediately after mixing, ensure adequate agitation is occurring in the tank and reduce the total water volume if at all possible.

Calibration

Spray nozzles wear resulting in increased output and variable distribution. Calibration improves spray application efficiency by minimising the amount of pesticide required for an operation and by ensuring that the sprayer produces the appropriate droplet spectrum. It is only through accurate calibration that the grower can be sure the correct effective dose of pesticide is being applied.

Sprayers that have been fitted with spray controllers require calibration to check the speed measuring device and the flow meter for accuracy. The operator manuals provide details for specific equipment. To calibrate any sprayer, the following equipment should be available:

- A calibrated jug or measuring cylinder (1 Litre)
- Tape measure (100m), calculator, notebook and pencil
- Stopwatch or wrist watch (with a seconds indicator)
- Small brush to clean nozzles (soft bristles)
- Performance and output charts for the nozzles or outlets to be used.

Preliminary measurements

A. Nozzle output (L/min)

- Check the pressure drop between the nozzle and the pressure gauge on the controls.

- Clean all the nozzles and filters thoroughly.
- Fill the spray tank with clean water and operate the pump at the specified RPM, and the nozzles at the desired pressure according to the nozzle charts.
- Use a calibrated jug to collect the output from each nozzle for one minute and record the volume.
- Compare this to the manufacturers nozzle performance tables and replace any outlets that vary by more than 10% from specifications.
- Note the number and type of nozzles per row of cotton (it may vary from 1 to 5, depending on stage of season).

Total spray boom output(L/min) = Sum of all individual nozzle outputs (L/min).

B. Operating speed (km/h)

- For tractors and groundrigs that are fitted with ground speed sensors, check equipment calibration under field conditions. Refer to the manufacturer's operating manual.
- For tractors and groundrigs that are not fitted with ground sensors:

  Measure out 100m in the field to be sprayed. Select the gear and RPM for comfortable operation and measure the time taken to cover the 100m that has been marked out. Do a couple of runs and average the times.

Operating speed (km/h) = Distance travelled (m) ÷ Time taken (sec) x 3.6.

Note: 3.6 is the factor that converts m/sec to kph.

C. Effective sprayer width (m)

Broadcast application:
Nozzle spacing (m) x Number of nozzles.

Row application:
Row width (m) x Number of rows being sprayed.

Band application:
Band width(m) x Number of rows being sprayed.

Table 43: Approximate band widths for different crop heights (1m rows).

Crop height (m)	Band width (m)
.10	.30
.15	.30
.30	.40
.40	.50
.60	.75
.80	.90
.90	.95
1.00	1.00

Spray calculations

1. Application volume (L/ha sprayed):

Note: Label directions refer to the volume applied per sprayed area. This formula calculates application volume per sprayed hectare.

Application volume (L/ha sprayed) = Total boom output (L/min) x 600 ÷ Tractor speed (km/h) ÷ Effective width (m)

Note: 600 is the factor that converts L / min to L / hr and kph x m to Ha / hr.

2. Flow rate for a known application volume (L/min):

Output (L/min) = Application volume (L/ha sprayed) ÷ 600 x Speed (km/h) x Effective width (m).

3. Amount of product to be added to the spray tank:

Amount (L or Kg) =Spray tank volume (L) ÷ Application volume (L/ha) x Product label rate (L/ha or Kg/ha).

4. Band / Paddock ratio:

Band / Paddock ratio = Band width (m) x No. of rows ÷ Sprayer swath width (m)

Solid planting (1m rows):
Sprayer swath = Number of rows x 1.0 (m)

Single skip planting (1m rows):
Sprayer swath = Number of rows x 1.5 (m)

Double skip planting (1m rows):
Sprayer swath = Number of rows x 2.0 (m)

If using tramline or irregular row widths, measure the distance from the centre of one spray run to the centre of the next spray run.

5. Amount of product required for the paddock area:

Product (L or Kg) = Paddock size (Ha) x Product rate (L/ha or Kg/ha) x Band/Paddock ratio.

6. Paddock area (Ha) that can be completed with each full spray tank:

Paddock hectares / tank = Tank size (L) ÷ Application rate (L/ha sprayed) ÷ Band /Paddock ratio.

7. Sprayer output per paddock hectare:

Output (L/ha paddock) = Application rate (L/ha sprayed) x Band / paddock ratio.

Suitable Conditions for Applying Pesticides

Environmental conditions have a large influence on how much of the product we spray actually reaches the target. Considerable losses of chemical can occur when spraying under adverse environmental conditions. The two major losses that occur are from drift and evaporation before the spray reaches the target.

Spraying in unsuitable conditions

When spraying in unsuitable conditions you are not only wasting money from wasted product, but you may also be reducing efficacy and therefore respray interval, as well as adding to possible resistance from delivery of sub-lethal doses to the target. Damage and/or contamination to sensitive areas, crops and pastures are also of major concern when drift is present.

Monitoring

Monitoring of conditions before and during a spray job is essential to ensure you are aware of changes in conditions as they occur. You must be able to record and keep a hard copy of weather condition data. Data may be obtained from a stationary weather station or from hand held equipment. Hand held weather equipment is advised to enable conditions at site of application to be monitored. It is suggested each time you refill that you check conditions. A good operator will be aware of changing conditions when spraying and take necessary action.

Most susceptible set-ups for environmental loses

Droplets under 250 microns (0.25mm diameter), classified in the Very Fine and Fine categories of the British Crop Protection Council (BCPC) specifications are the most susceptible to drift and evaporation. For this reason extra care should be take when spraying by ground and air with set-ups that are classified in these categories.

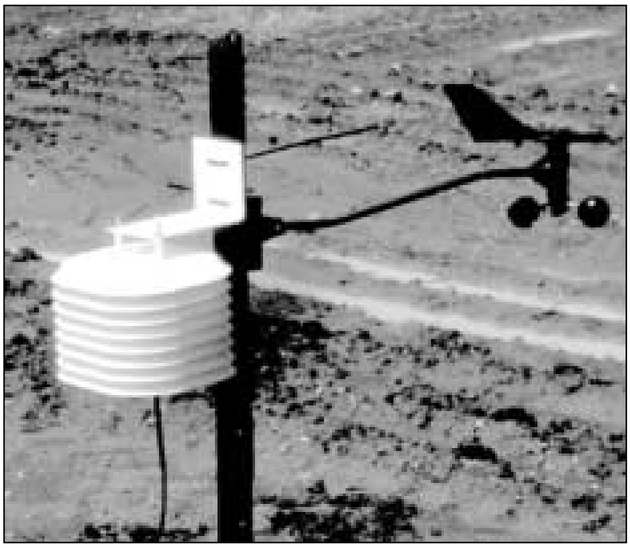


Figure 27: Stationary in-the-field weather station.

Wind Speed: 1 to 4.2m/sec (3kph to 15kph)

Some wind is needed to be present to ensure penetration into the crop and to prevent stratification of air layers (further discussed later). Wind less than 3kph is generally unpredictable in direction. High wind conditions can cause increased downwind drift potential. Always be aware of the wind direction and what areas/crops are downwind from where you are spraying. All spray aircraft should be fitted with on-board exhaust 'smokers' for determination of prevailing wind direction. They may also be used to indicate relative strength of the wind and to some extent the amount of turbulence or inversions present. To assist in aerial application growers or ground crew can light bonfires so the smoke can show prevailing winds and further assess the suitability of conditions to spray. A wet bale of hay burns slowly and creates a visible white smoke for assessing conditions.

Spraying under calm, high or variable wind conditions is not recommended.

Temperature:

Morning: Up to 29°C

It has been shown that once temperatures have risen above 29°C significant losses in spray can occur before spray deposits reach the target.

Afternoon: Below 32°C and as long as the ground temperature is cooler than the air temperature.

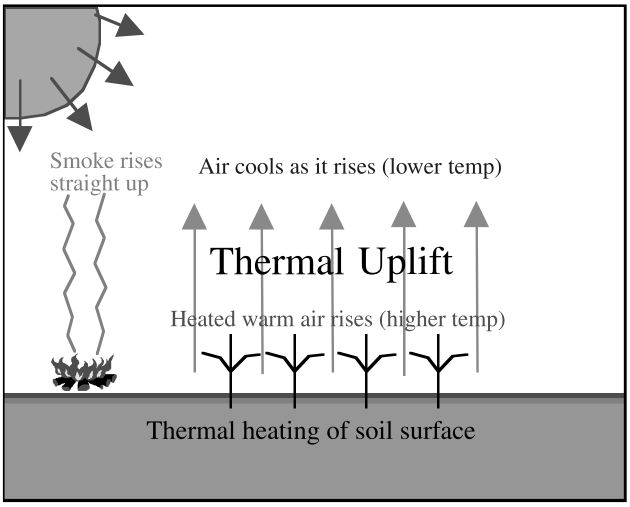
If the ground temperature is hotter than the air temperature which has begun to cool in the late afternoon it is probable that thermal uplift is occurring and therefore conditions are not suitable for spraying.

Thermal Uplift:

NO spraying should occur during thermal uplift

Thermal uplift is when the hot ground heats the air near it and the hot air rises. Under thermal uplift it is harder for droplets to fall (against the rise of air), hence droplets may be carried up instead of falling and evaporate or drift off target.

Figure 28: Air movement in Thermal Uplift.



Thermal activity can be detected by measuring a higher ground air temperature than the air temperature above the crop. Smoke can be used as an indicator, which will continue to rise as the hot air rises.

Relative Humidity:
Relative humidity is a measure of moisture in the atmosphere expressed as a percentage of the total amount of moisture (saturation) which the air can hold at a given temperature.

As relative humidity increases the potential for evaporation decreases as the air becomes saturated with moisture. When relative humidity is low, water based sprays can evaporate quickly and product can be lost. In general, spray when the relative humidity is high (that is when the difference between wet and dry bulb temperatures is less than 10°C (see **Table 44**, next page)).

Inversions & Cold Air Drainage:

NO spraying should be carried out under an inversion or cold air drainage.

Inversions are when there are two air masses present of differing temperature, which do not mix. They are common on nights with limited cloud cover and light to no wind. Sprays released above an inversion may not reach the target due to the unmixed layers of air. Sprays released below an inversion remain concentrated and if drift occurs, concentrated levels of chemical may move off target and cause damage.

Inversions can be identified with smoke indicators when smoke will layer and move laterally in a concentrated cloud. If the spray from ground or aerial application tends to hang above a crop it is likely there is an inversion present and you should stop spraying until conditions become favourable.

Cold Air Drainage

Air acts as a liquid and as it cools it falls and drains to the lowest point, this is known as cold air drainage. It is most common in the late afternoon/evening when sometimes you can feel the cooler air moving in. It is important to consider possible cold air drainage when you are spraying. The low point which the air drains to could be in the same paddock, a neighbouring gully or another crop on lower ground. Smoke indicators may visually indicate if this is occurring. Cold air drainage can be responsible for off target loses and damage to sensitive areas.

For more information refer SprayPAK.

Figure 29: An inversion layer.

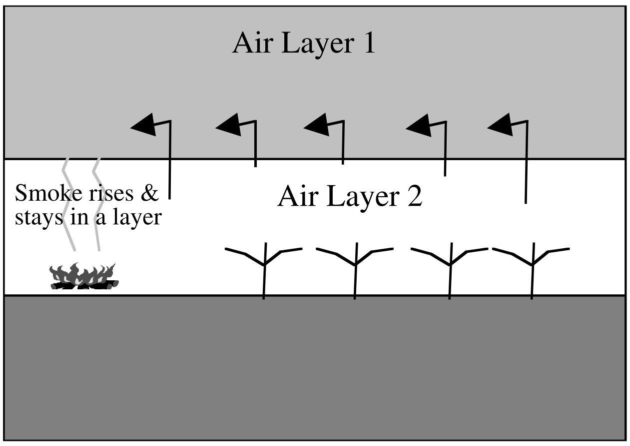


Table 44: Temperature and humidity levels for optimum spraying conditions. The Stop & Go spray chart.

	Temperature (°C)								
RH (%)	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0
100	Application is not recommended due to the risk of rainfall and loss of pesticide.								
90									
80									
70									
60									
50									
40									
30									
20									
10									

Note: This is a guide only. All weather parameters and spraying operations must be monitored during spray operations, and BMP (PAMP) guidelines followed.

	Best option for most situations
	Suitable option for spray application but caution recommended
	This option is not recommended

By Rachel Holloway, CRDC

Developing Pesticide Application Management Plan (PAMP)

KEY POINTS:

- **Contact your neighbours before spraying.**
- **Document your Pesticide Application Management Plan. Contact Cotton Australia.**
- **Ensure grower, applicator and consultant know their responsibilities.**

The following information can be used for aerial or ground applications, and will help growers in New South Wales and Queensland meet their legal obligations in relation to pesticide use. For further information on developing a PAMP refer to the *Australian Cotton Industry Best Management Practices Manual*, Application of Pesticides.

Safe pesticide use includes the following:

- Neighbours – by communicating effectively with neighbours to ensure that everyone is aware of what is happening with pesticide use and has the opportunity to discuss any concerns.
- Responsible owners and managers – by communicating effectively and constantly with applicators (groundrig and aerial) and consultants to ensure the most appropriate pesticide is applied effectively and safely to the target
- Users of 'Best Management Practice' – will help growers identify and minimise the risks to people, property and the environment.

Before the start of each season, organise a meeting with representatives from all groups involved in spray application decisions. Draw up a plan that addresses each party's roles and responsibilities.

The following issues need to be documented when developing a PAMP:

- Develop of a farm map
- Pre-season communication with neighbours
- Discuss application requirements with consultant, applicator, workers pre-season
- Make sure arrangements for in-season communication with neighbours, consultants and applicators are followed
- Worker awareness of applications
- Monitoring and recording of weather conditions
- Application of pesticides in appropriate conditions.
- Use of buffer zones near sensitive areas
- Training of people involved in pesticide supervising, using and handling
- Choice, calibration and maintenance of equipment
- Record keeping requirements for ALL pesticide applications
- Compliant handling procedure for application.

The following responsibilities need to be agreed upon by the grower, applicator and consultant before the start of the season.

GROWER RESPONSIBILITY

- **Identify hazards and risks on and off farm; people, property and the environment, for example: on the farm map.**
- **Arrange pre-season meetings with neighbours, consultants and applicators.**
- **Adhere to agreed responsibilities and communication arrangements with all parties (i.e. applicators, consultants, staff, chippers, field workers and neighbours).**
- **Application orders are to be in writing to the applicator.**
- **Determine and record appropriate weather conditions for each field and ensure these are clear to the applicator (inc. wind direction, wind speed, temperature and humidity).**
- **Monitoring of weather conditions during the application.**
- **All people handling or using pesticides should be appropriately trained.**

APPLICATOR RESPONSIBILITY

- **Applicator should be trained and licensed for the application of pesticides.**
- **Ensure pesticides are applied according to label dirtections.**
- **Ensure equipment is well set-up, maintained and calibrated appropriately**
- **Knowledge of identified sensitive areas and hazards on farm.**
- **Adhere to agreed to responsibilities and communication arrangements made with grower and consultant.**
- **Giving written confirmation on completion of the job (and any notification of delays).**
- **Ultimate responsibility to decide to complete the job if weather conditions change. Unless asked to pull-out by the grower.**
- **Aerial applications should not be carried out within 100 metres (QLD) or 150metres (NSW) of dwellings without the written consent of the occupants.**

CONSULTANT RESPONSIBILITY

- **Sound knowledge of techniques and technology available to reduce pesticide use**
- **Clear working knowledge of the grower's P.A.M.P.**
- **Recommendations in writing; within label directions; include alternatives if changing conditions are likely.**
- **Adhere to agreed responsibilities and communication arrangements made with grower and applicator.**
- **Ensure that the grower is aware of all application recommendations.**
- **Reconsider or recheck the crop when delays occur.**
- **Highlight constraints when discussing recommendations with growers.**

COMPLAINT HANDLING:

This may be useful information when handling application complaints:

DURING APPLICATION

- Suspend application and discuss reasons for concern,
- Resume application if agreed between growers, compliantant and applicator. All parties must be confident that application is occurring within agreed parameters.
- Cancel application if no agreement is reached;

or

- Where agreement cannot be reached, an independent party should be contacted to assist with resolving the conflict.

AFTER APPLICATION

Complaints received by the Environmental Protection Authority (QLD or NSW) will be referred to the grower or operator for resolution.

- Grower to discuss matter with complainant and operator.
- Complaints received by applicators should be referred back to grower.
- Appropriate authorities to be notified immediately of unresolved complaints are:

Environment
– Environment Protection Authority Qld & NSW

Cotton Industry
– Cotton Australia, Cotton Grower Associations

Crops and stock
– Department of Primary Industries / NSW Agriculture

People and buildings
– Division of Workplace Health & Safety (QLD), WorkCover Authority (NSW)

By Gus Shaw, NSW Agriculture

COTTON DEFOLIATION

Before mechanical cotton pickers were invented, the requirement for hand harvesting was only the opening of bolls. This allowed the greatest preservation of natural cotton fibre properties and yield. On Australian cotton fields where mechanical harvesters gather up the seed cotton, the leaves must be removed from the plant to prevent contaminating the lint. This preparation is known as defoliation.

An October sown crop will show first open bolls around mid-February. The rate bolls open is temperature dependent, ranging from 2% to 3% per day and up to 5% as boll opening progresses. Cooler, short season areas such as the Central Downs and Breeza Plain will be slower than other areas.

Conditioning (or defoliation) usually should occur when the top harvestable boll is mature. The two common methods used to determine boll maturity include first examining seed maturity inside the developing boll, and, second, the nodes above cracked boll (NACB) method.

In some years with ideal growing conditions, some degree of vegetative growth control may be necessary mid-season to ensure the plant remains manageable for later pesticide and defoliant applications, and picking. The use of a growth regulator, applied once or as a lower rate split application, may be warranted under these conditions.

Terminology

The basic terminology is worth defining before discussing the tools and strategies of this facet of cotton production.

Conditioning and / or defoliation (by artificial means) describes a management practice which aids the formation of abscission layers in the leaf petioles and results in the desiccation or shedding of foliage earlier than would have occurred naturally. It artificially prepares a crop for harvest. Chemicals used to condition and defoliate include dimethipin (Harvade®), and thidiazuron + Diuron (Dropp Ultra®) for cool conditions, thidiazuron (Dropp WP®) for hot conditions, ethephon (Prep®), ethephon and AMADS (CottonQuick®) and ethephon + Cyclanilide (Finish®).

KEY POINTS:

Defoliation

- **Hot temperatures are best for more effective defoliation results.**
- **Optimum timing of defoliant spray is important for efficient defoliation and to maximise lint quality.**

Contamination

- **Careful management, good agricultural practices, harvest crew induction and attention to harvest hygiene are essential to contaminant-free cotton.**
- **Failure to follow basic guidelines could prove costly.**

Picking

- **Secure contractor early.**
- **Coordination and planning equipment and staff is essential .**

Desiccation or the rapid drying and death of foliage is often used to describe conditioning and defoliation. Desiccants include diquat (Reglone®) and paraquat plus diquat (Sprayseed®), and sodium chlorate (Atlacide®, Leafex®).

Plant growth regulators are compounds applied directly to a target plant to alter its phenology or its structure to improve quality, reduce disease risk, increase yield or facilitate harvesting. Mequat chloride (PIX®) and ethephon (Prep 720®) are the only growth regulants used in cotton.

A synergist is a chemical which increases the action of another e.g. Endothal (Accelerate®).

A wetting agent is a substance that by reducing the surface tension of a liquid allows it to spread on the leaf surface or penetrate the leaf cuticle e.g. D-C-TRON.

Objectives

From March through to May each year, cotton growers in the various growing areas, covering both short and long season districts, begin the defoliation process to:

- Remove the leaf canopy or foliage to allow more efficient operation of mechanical pickers
- Promote earlier picking
- Eliminate material that could stain cotton fibres
- Reduce the trash content of seed cotton.

When to defoliate

The aim in timing a defoliant application is to apply the material when the crop is physiologically mature. Physiological maturity is defined as that time when the crop has put all available nutrients into its reproductive tissues and has started to slow its transpiration rate prior to natural senescence.

Physiological maturity is determined by several well accepted methods. The first is by examining seed maturity inside the developing cotton boll. Bolls that are difficult to cut using a sharp knife and show no "jelly" within the developing seed will be harvestable after a defoliant is applied. The seed coat (on a cross section) should be turning brown (seen as a distinct brown ring within the immature seed coat). The second well accepted method is the "nodes above cracked boll" method. This method shows that the last harvestable bolls occurs 4 nodes above the most recently cracked (opening) boll.

Defoliating when the crop is physiologically mature is a more reliable method than the previous reliance on a percent open boll threshold. The relevance of this method is greatly influenced by the length of the fruiting period. A crop set over a six week period might incur a yield penalty if defoliated at 65% open, while one set in three weeks might be safely defoliated at 40 to 50% open because all bolls are maturing at approximately the same time. Percent open bolls may be used as a guide but should not be used as the sole criteria in determining when to commence defoliation.

When determining crop and plant maturity, all of the above methods should be used in conjunction with each other to select the correct time for defoliant application. Ideally defoliation should commence when the last desired harvestable boll is physiologically mature.

Boll opening

Modern cotton production has worked towards a single picking. The economics of second picking cotton have to be carefully assessed. Boll openers like ethephon (Prep720®) and defoliation enhancement products like CottonQuick® and Finish®, help speed up the time required for all the bolls to open. These products will open immature bolls as well so they should not be applied too early.

HOW

The grower, keeping these objectives in mind, can assess the particular techniques required to successfully pick the crop confronting him. The questions most commonly asked involve - whether one or two defoliant sprays are needed; is a pre-conditioning spray going to benefit? When should the first application be applied? What chemicals should be used? and how long after the first spray should the second one be applied?

The major problem situations are:

1. Lush rank crops where sufficient mature bolls exist and the grower feels the need to defoliate.
2. Crops with extremely heavy boll loads that have lodged creating thick impenetrable canopies.
3. Late crops where the grower has anticipated a better top crop and faces cold temperatures.
4. Frosted crops also present special problems.

These situations are special events and may require specialist treatment, however for the industry generally, several classes of crops can be briefly discussed here in relation to defoliation techniques.

Perhaps the easiest crop to defoliate is the one which has "cut-out". Vegetative growth has ceased, natural senescence has started to occurr and abscission layers are clearly defined. The whole canopy being reasonably uniform can usually be successfully defoliated using a single application of Dropp Ultra®, or sodium chlorate (known here as Chlorates). The grower has merely to check that the top bolls are mature. The crop that completely cuts out may be one where soil nitrogen was depleted early or successfully managed so as to run out in March. Alternatively drought or mite damage can produce partially defoliated crops.

A second, and common, crop situation is where lower bolls are opening while the top bolls are firm and surrounded by an active canopy. Some growers use two applications of chlorate in this type of crop. The prerequisite for the first application is that the top bolls are mature. The second spray may follow in 7 to 14 days depending on the quality of the first spray. An alternative technique is to use Dropp Ultra® or Dropp WP® depending on temperatures. These chemicals can be used at varying rates or mixes to create numerous degrees of defoliation.

Never mix a defoliant with a desicant and never follow a desicant with a defoliant.

A common practice is to apply a moderate rate once the top bolls are mature followed some 7 to 10 days later with a chlorate spray, or Prep 720®, CottonQuick® or Finish®. The initial spray is known as a conditioning application and aids in the formation of abscission layers in the leaf petioles. By moving through a field and assessing the ease with which leaves can be made to fall from the bush, the timing of the second spray can be easily determined. Once the lower leaves have been exposed the second application can easily reach these lower leaves.

The need for two applications of a defoliant may exist where ever a big crop is grown, though not necessarily rank and active, and where there is a necessity to obtain better defoliant penetrations to lower leaves.

A third crop situation encountered, particularly on new fields and high nitrate soils, is the rank crop. The use of PIX® should be considered in season in the management of these crops. In these situations the grower needs to identify the top harvestable boll and ignore those bolls that won't mature by harvest. Once the top harvestable boll is mature defoliation can proceed. A crop of this sort may have 45% of the bolls open while still producing luxuriant top growth. One technique for managing this predicament would be the initial application of a low rate of defoliant to slow down the crop and encourage the plants towards maturity. Around 7 to 10 days later a higher rate of defoliant can be used which will further induce hardening of bolls and formation of abscission layers. The final defoliant spray can usually follow some 10 days later and may be a chlorate application.

Partially irrigated crops and dryland crops that have suffered moisture stress are sometimes very difficult to defoliate. High rates and a change to desiccants are sometimes necessary to prepare the crop for harvest. Crops that are to be harvested by stripper pickers must be defoliated completely to prevent lint staining and dockages.

The adherence to a set defoliant 'recipe' no matter what the conditions are like should be avoided. Each crop, because of its different cultural and agronomic history, will need to be judged on a field by field basis. Temperatures at time of defoliation will also influence rates and product selection.

Various mixes and chemicals can be used, including Dropp Ultra® Dropp WP® Prep 720®, chlorates, CottonQuick® and Finish®.

Dimethoate is sometimes mixed with the defoliant to control aphids whose "honey-dew" can adversely affect the fibre quality. Past experiences have indicated that mixes with chlorate should be avoided. Care should be taken when tank mixing products. For example, mixing organophosphates and sodium chlorate can cause an explosion.

Mixtures of Dropp®/Prep® with Glyphosate have been used to successfully defoliate cotton. This mix can be used as a single spray system or as a second hit mix. The Glyphosate is effective in reducing regrowth and green staining while providing a degree of weed control if required.

Chemicals which enhance the activity of conventional defoliants are now widely used. The most common additive is a derivative of ethephon (Prep720®) and is most often used in a mix with the first or second application. These additives have negated the use of a following chlorate spray. The use of surfactants can also improve the defoliation job.

Desiccants are sometimes used in cotton defoliation, the most common chemicals being diquat or Sprayseed® (ground rig application only). Frost frozen crops can be made to "pop" open using desiccants. The major danger with this form of chemical is that leaves tend to be "frozen" onto plants because of the very rapid death which can lead to increased trash problems.

Numerous other substances have been used for defoliation in the past. Cacodylic acid, calcium cyanamide, dithiin tetraoxide, ammonium nitrate and anhydrous ammonia have all been used. These compounds need to be assessed in the light of the objectives of defoliation.

ISSUES

Successful defoliation is not a foregone conclusion. The problems and factors which need consideration include:

(a) Defoliation enforces a cessation of further fibre and seed development

(b) Excessively early defoliation can inhibit the opening of immature bolls

(c) Desiccated leaves can create increased trash problems

(d) Frosts can cause leaf and boll "freezing"

(e) Rain following a defoliation spray may create variable results

(f) Cool weather or active plant growth will retard the rate of the defoliant activity

(g) Spraying is most effective when wind turbulence will allow greatest movement of chemical around the lower plant parts. Large droplet size will favour the shock effect of the chlorates, swarth widths are usually reduced when applying defoliant.

(h) Both the over or under use of defoliants can represent an adverse economic cost.

(i) Drift of defoliants onto trees and other vegetation must be avoided to prevent damage.

(j) In dryland situations especially skip-row configurations there is an excellent opportunity to use a ground rig for defoliation. Final coverage is very important and a minimum of 100 litres per sprayed hectare should be used.

SUMMARY

Many factors control the success of a defoliation application. They involve plant growth, weather, spray coverage, chemical degradation, chemical absorption and translocation which contain both controllable and uncontrollable inputs for the grower. There is a need to produce manageable crops where nitrogen run-out can be controlled. This task becomes easier after several seasons of cropping.

Finally, when the cotton producer confronts the crop at defoliation time, an assessment of the objectives, the grower's needs and the tools and techniques available has to be made to successfully pick Australia's high quality cotton crop.

CONTAMINATION OF COTTON

Contamination of cotton with foreign substances lowers the value of the product and often causes problems and increased costs for those processing the cotton at both the ginning and spinning mill stages.

Contamination occurs in many ways. There are natural agents such as leaf, bracts and bark which occur at the harvesting stage, excessive green leaf causing discolouration and sometimes spotting, weed contamination – especially burrs and grass which are harvested with cotton, and honey dew produced by aphids which causes a sticky sugary substance to foul the cotton.

Many of these natural contaminants can be avoided with careful management and good agricultural practices both prior to and during harvest. Rain on a crop which is ready for harvest can often exacerbate the cleaning of these natural contaminants especially leaf and bract trash.

Picking cotton which is too moist, particularly when that cotton may be stored in a module for some time, can lead to sweating and subsequent discolouration or spotting. Thus, moisture can also be regarded as a contaminant. Picking too early when the dew is on the cotton or picking too late into the night when the moisture level rises can lead to deterioration in quality.

There are also man made contaminants. Synthetics such as plastic and twine, oils used in module builder hydraulics, grease from spindle and bar lubrication in picker heads, and food wrappers and drink bottles from equipment operators, can also find their way into a grower's module. Mostly these man made contaminants can be eliminated. Failure to clean the grids on the tops of picker baskets often means that dirty, immature fibre is dumped into a module of high quality cotton thereby threatening to reduce the value of some bales from that module.

From time to time gins find pieces of metal and equipment in modules which can damage ginning equipment and cause fires within the gin.

Contamination also occurs from the failure to properly protect modules from the elements. A range of tarping materials is used and generally the ginners find that the well designed, fitted tarps provide the best protection. Many growers only see their modules on-farm following construction. During transport to the gins modules are often stretched and covers and ropes dislodged. In the yard ginners often have to cover modules that arrive in poor condition or whose ropes and plastic sheeting have become dislodged. Rain and windy weather can lead to damage to the cotton if it is able to penetrate through torn or loose covers. Cotton contamination caused by moisture is a serious problem at the gin. As the cotton module is fed into the feeder head with spike rollers and drop down into the J where it is mixed with hot air in preparation for ginning, localised pockets of contaminated cotton are mixed and distributed contaminating the entire module.

All contaminants lower the value of the final product and can potentially damage Australia's reputation as a supplier of quality cotton. Problems caused by contaminants include:

1. Increased trash leading to a higher chance of pin trash and lower grades which reduces the value of the fibre.
2. Increased need for more lint cleaning which can affect fibre quality.
3. Reduced out-turn at the gins due to the sheer weight of trash and sometimes the loss of fibre caught up in burrs and sticks.
4. An increased risk of gin fires due to rubbish causing sparks, or increased rubbish leading to tags at the gin stands and often gin stand rib fires.
5. Grass and bark in cotton is difficult to completely remove since it becomes shredded during ginning and behaves just like fibre. Spinning mills too, find it hard to remove and often the fibres go right through to the final product. The cost of bark and grass can be high. For example: Middling light grass can be discounted by $20 per bale while light bark bales can be reduced in value by $30. Heavy bark sees the discount rise much higher.
6. Plastics, especially ones that shred and form into fibres, such as bailing twine, can lead to synthetic pieces appearing in fabric. This often renders the product useless or of considerably less value. A claim on the processor or merchant, often many times higher than the value of the bale, can often result.
7. Excessive green moist leaf in the module can lead to spotting which lowers the value of the module. For example, a light spotted bale can be discounted up to $24 per bale. At 7.5 bales per hectare this equates to $180 per hectare lost! In cases where the spotting becomes severe a spotted middling cotton can be discounted by around $70 per bale. On a 7.5 bale per hectare crop this amounts to $525 per 100 hectares.
8. Honey dew causes problems for the spinning mills. Instead of being able to draw thin strands of fibre, the honey dew causes the cotton to stick to spinning equipment causing breakages and uneven yarn. It will also affect dye uptake. Discounts for honey dew can be extremely high.
9. Oil, grease and other contaminants which discolour the cotton lead to uneven dyeing and can leave off-coloured threads in the finished fabric. Oil gums up spinning equipment and contaminates fibre being drawn into fine yarn.

Australia is recognised as having the highest standards in the world in the cleanliness and freedom from contamination of its cotton. This standard must be maintained and the responsibility for keeping Australian cotton clean and contamination free rests with everyone involved in growing the crop, preparing it for harvest, harvesting and module construction, transport to the gin, ginning and shipping to the mill. Contamination can occur at any one of these steps.

By far the largest contribution to contamination occurs at harvesting and module building time. A site inspection prior to putting down a module is a must. Rocks, a common form of contamination, can be avoided if an inspection is carried out. Often contamination occurs because of ignorance. The actions of people involved at harvest time can often inadvertently lead to substantial down grading of a grower's cotton. The lunch bag that blows into the module builder, the bailing twine that is used instead of proper rope on tarps can often badly contaminate a module, the leaking module tramper ram that is left unattended can result in severe oil contamination.

Plastic and other synthetics which become shredded and mix in with the lint can render garments unsaleable or heavily discounted and the cost to processors and growers can be many times the value of the bale. Often these substances are on the ground before a module is built – a piece of rag, remnants of a fertiliser bag, a piece of wire – and the module built on top of them is contaminated. A site inspection before putting down a module can prove very useful. Providing crews with a garbage bin in which all waste is thrown can also be beneficial.

All module building crews should be trained to watch out for contaminants. Make them aware of the potential problems and provide them with the facility to clean up and isolate rubbish. When ground crews sweep up cotton that has spilled around a module make sure they don't sweep up contaminants or excessive dirt and place it in your module.

Failure to clean the top grids on a regular basis leads to unwanted waste and very dirty cotton getting in with the more valuable lint from the basket.

Keeping Australia's high quality cotton contaminant free is essential – it is the responsibility of all involved from growing through harvest to shipping to watch out for contamination.

HARVEST

Picking

Cotton picking is a specialised operation requiring two machines, a spindle picker or stripper harvester, and a module builder. Many current growers are fully equipped for owner operation whilst new growers need to decide on buying machinery or using a contractor.

For new growers, the use of contract harvesters is recommended. It is difficult to justify the purchase of harvesting equipment, particularly if the enterprise could be abandoned after one season. For those with longer term intentions, fully reconditioned pickers are available but used module builders may be scarce for those wanting to purchase their own equipment. Another option is to form a pool arrangement and share with other new growers.

Moisture content in the cotton determines the start of picking, the length of picking day (early starts and late finishes) and (failing breakdowns) the uninterrupted continuation of picking until harvest is completed.

Harvest should commence when the moisture content drops below 12%. A moisture meter can be used or the seed can be bitten: it will crack if ready for harvest.

Excessive moisture in cotton causes spindle wrap (difficult for the gin to handle) which leads to lower out-turns, lower quality cotton and lower returns to the grower. Spindle wrap will also lead to a very poor picking job, it could also cause head chokes which are a major cause of fires.

Wet cotton in the module also results in increased temperatures with a subsequent deterioration in both the quality and quantity of cotton ginned. Quality loss depends on how wet and for how long the wet cotton remains in the module before ginning. Wet cotton is also more likely to result in cavitoma caused by microbial degradation of fibre.

Wet harvests have shown that the decision to start, and / or continue picking is not that simple. There will always be trade-offs between the chance of further rain versus getting the crop off, and the damage this can cause if cotton is too wet. Growers need to be aware that picking well into the night may be good in terms of completing harvest, but disastrous in relation to potential quality damage.

The spindle picker

Spindle picking is generally the slowest and most expensive way of harvesting cotton.

Spindle pickers have the advantage of being able to operate under a wide range of crop conditions and in both high and low yielding crops, generally producing higher out-turns (less trash). In high yielding crops, spindle pickers are superior to stripper harvesters.

A great deal of care and attention should be paid to setting up a picker and maintaining these settings during harvest. At all times follow the manufacturer's instructions. Correct height adjustment of the picker heads, and proper adjustment of pressure doors, doffers and moisture pads will guarantee efficient picking and result in better quality and greater quantity of cotton harvested.

Cleanliness of the picker basket is very important. The top of the basket and grid bars should be cleaned regularly to avoid contamination of clean cotton as it is emptied into the module builder. Chute doors should be cleaned regularly to prevent build up of mud and rubbish which can cause blockages in the chutes and possibly lead to a fire in the heads or in the basket. Failure to clean leads to dirty cotton, more pin trash, lower uniformity ratios, lower micronaire, lower quality and thus lower returns to the grower.

Stripper harvesters should not be used to second pick a spindle field, as the quantity of trash makes it impossible to gin.

Extreme care is necessary when setting up pickers whilst heads are engaged or when operating any machinery near power lines.

The stripper harvester

Stripper harvesting is generally the cheapest way of harvesting dryland cotton.

Stripper harvesters must be fitted with pre-cleaners.

Stripper harvesters can harvest both high and low yielding crops. On crops of less than around 3.5 b / ha, they are cheaper to operate than spindle pickers. In lower yielding crops a higher proportion of the bolls, those more difficult for spindles, will be harvested resulting in a higher yield.

Stripper harvesters have a lower out-turn than spindle pickers (29% to 32% compared to 36% to 38%), and cotton may be a half grade lower ($14 discount per bale) compared to spindle pickers. In some instances there has been a full grade difference. There is a higher risk of lower micronaire as more immature bolls may be harvested while excessive bark can also result in a discount of $20 per bale.

MODULES AND IN-FIELD HANDLING

Modules are an aspect that some growers pay a lot of attention to and others very little. Even, well compacted, consistent modules, dome shaped on top to shed water, should be the objective.

Properly built modules are easier to move, shed water, don't break apart, contain more bales and are thus cheaper to transport per unit.

Modules should always be built in flood free areas, free of rocks, with easy truck access and never built under or adjacent to powerlines. Ideally they should be on mounded compacted pads with all weather access a further advantage.

At no time should an operator work on or in a module builder when the harvester is unloading.

Avoid contamination of any kind. Regularly check hydraulic fittings. Blown hoses can spray oil over the module, contaminating the cotton causing severe downgrading. Other contaminants, particularly plastic in the module will also cause severe downgrading.

Module tarp covers are an item commonly overlooked by growers. In some cases, this can be an expensive oversight conservatively costing the grower between $50 and $60 per bale due to downgrading of cotton during a wet harvest.

Tarps are designed to protect modules in the field. Modules can be valued at anything from $8,000 - $10,000 and up to $15,000 depending on the price of cotton. Skimping on module covers can easily cost far more than the value of the tarps in downgrading during a wet harvest.

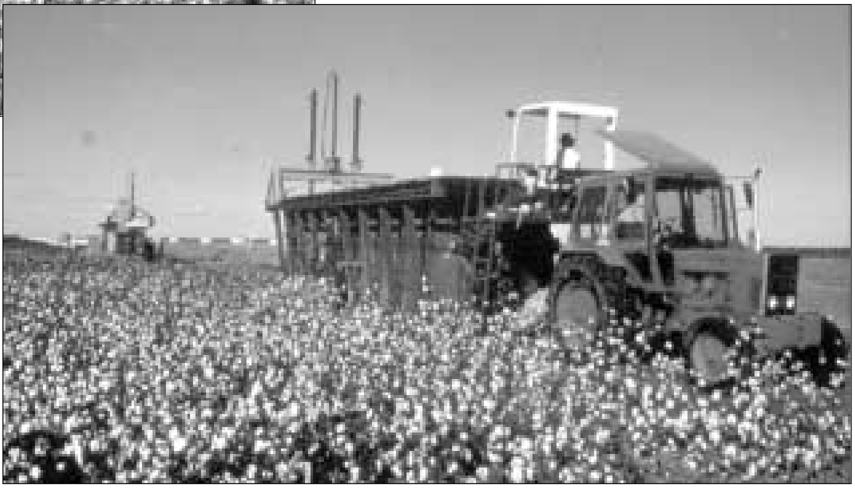
Tarps should be checked annually for holes and either repaired or replaced. Old tarps should also be inspected to ensure that they are not worn out and that the weave is still in good condition and not starting to let go.

Poorly built modules tend to be flat on top encouraging water to pool during a wet harvest. If tarps are holed, or old or worn out, water seeps into the cotton resulting in losses through rotting, heavy spotting and contamination resulting in severe downgrading.

Care should also be taken with the way tarps are tied down. Ropes tend to channel water into the module. It is best if ropes are covered by flaps to prevent this problem. Modules should be sited away from floodways and areas of poor access after rain.

Module handling is a relatively expensive operation which is organised by contractors. Costs are made up of the module lift plus one way distance of travel to the gin. Chain beds are used for short hauls. Flat beds and in-field loaders are more economic for longer hauls.

Left: Harvesting dryland cotton.



Right: Module makers in the field

Left: Cotton classing using the latest High Volume Instrument (HVI) system.

Right: The traditional method of classing cotton.

GINNING, QUALITY & CLASSING

By Robert Baird, Queensland Cotton

KEY POINTS:

- **The crucial stress period, particularly for fibre length, strength, and to some extent, micronaire occurs during the 20 day period following peak flowering. Stress during this time can adversely affect quality.**

Raingrown cotton is ginned and classed in exactly the same way as irrigated cotton, and under average to good growing conditions, the quality of each is similar. When seasonal conditions are more extreme, however, raingrown cotton lint quality can be inferior and can receive a range of discounts, some heavy. This is particularly so in very dry seasons and in situations where raingrown cotton has been planted late. The main quality characteristics of raingrown cotton affected by adverse conditions include: staple length, micronaire and grade, which are discussed in the relevant sections below.

GINNING

Cotton ginning is the process of removing the fibre from the seed and baling it into 227kg bales – thus making it a saleable commodity to spinning mills. The process includes cleaning both seed cotton and lint to remove trash collected during mechanical harvesting. The gin cannot perform miracles. It cannot improve quality; it can only preserve it. To do this task, a ginner's options are limited to moisture control, the amount of cotton in the cleaning machinery at a given time, bypassing certain machinery and adding moisture at the press. The importance of good agronomy, the best conditioning possible, clean and efficient picking and careful placement of modules are of the utmost importance in obtaining good grades. In effect, the grower to a large degree is setting his grades in the field.

QUALITY AND CLASSING

The role that quality plays in the marketing of cotton is unique among all other field and fruit crops. Cotton quality alone can be expressed by a multitude of measurements performed by cotton classers and described in the wide range of grades set out in **Table 45**.

The price received for cotton is dependent on these quality gradings and can vary substantially from quoted prices accordingly. Base cotton prices are quoted for 31-3, 1$\frac{3}{32}$ inch length, 3.5 to 4.9 micronaire. Premiums and discounts apply for higher and lower grades respectively. Discounts are also applied for either very coarse (high micronaire) or very fine (low micronaire and immature cotton).

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 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 composed of three components: trash, preparation, and colour.

Greater detail on cotton quality and grade is available from cotton classers, and only the most important points are included in this section. The characteristics of quality which directly influence price, are:

- Colour
- Trash
- Preparation
- Staple Length
- Micronaire
- Strength
- Extraneous Matter

Colour

The colour groups reflect the varying amount of colour from white through spotted and yellow to gray. True colour can only be assessed under light conditions which are set for universal testing.

Colour difference can only be observed when compared with universal standards.

Colour refers to the graduations of whiteness and yellowness in the cotton. The official USDA colour grades are listed in **Table 45** on the following page.

Table 45: Cotton grades, and codes.

GRADE	CODE	GRADE	CODE
Good Middling	11	Good Middling Spotted	13*
Strict Middling	21	Strict Middling Spotted	23
Middling	31	Middling Spotted	33
Strict Low Middling	41	Strict Low Middling Spotted	43
Low Middling	51	Low Middling Spotted	53
Strict Good Ordinary	61	Strict Good Ordinary Spotted	63
Good Ordinary	71	Strict Middling Tinged	24*
Good Middling Light Spotted	12*	Middling Tinged	34
Strict Middling Light Spotted	22*	Strict Low Middling Tinged	44
Middling Light Spotted	32*	Low Middling Tinged	54
Strict Low Middling Light Spotted	42*	Strict Middling Yellow Stained	25*
Low Middling Light Spotted	52*	Middling Yellow Stained	35*
Strict Good Ordinary Light Spotted	62*		

***Denotes descriptive grades. All other grades are represented by physical standards.**

Leaf grades are identified by numbers 1 through 7, all represented by physical USDA standards.

Other criteria will be reported as Level 1 (light) and Level 2 (heavy).

This includes poor preparation, excessive neppiness, presence of any substance other than fibre or leaf, such as grass, bark, stickiness and contaminants.

Mature cotton, when the bolls first open, is white and clean. Yellow colour may be a consequence of premature cessation of development by frost, drought or early harvest aid application. Gray is largely a result of exposure to moisture and field weathering. Weathering can be controlled, but the risk of weathering damage can be reduced by minimising the time between first and last boll opening. Fungal development, or sugars on the lint due to honeydew from aphids, can also produce gray cotton, but this can be managed by controlling aphids before they produce significant honeydew. Under certain circumstances, e.g. drought stress, raingrown cotton can produce more light spotted grades than irrigated cotton. Otherwise colour tends to be similar.

Trash

Trash represents the non lint particles such as leaf, bracts, bark and grass, most of which can be removed by lint cleaners during ginning. However, any major adjustments during ginning or milling to remove trash also removes lint and reduces gin out turn. Bark and grass can be more difficult to remove because they align with the fibres, and are a major problem in milling. Grass and/or bark or honeydew in the sample will result in a discount of the order of US$10–$50/bale. High trash levels are due to poor defoliation, inadequate harvest management, excessive weed infestations and, to a lesser degree, inadequate gin cleaning. Certain factors decrease leaf drop and thus the harvest of clean, dry seed cotton, which can be ginned for high quality. These include:

- Hairy leaves (not present in current varieties)
- High residual nitrogen (not usually a problem in raingrown)
- Rapidly growing juvenile plants (poor boll set or late cotton)
- Ample soil moisture
- Disease free plants
- Regrowth (due to rainfall at defoliation or just prior to harvest)
- Cool temperatures for five days following crop conditioning
- How much humidity before and during crop conditioning
- Water stress before crop conditioning (common problem in raingrown)
- Excessive conditioner or desiccant application
- Inadequate conditioner or desiccant rates

Many picking problems can be avoided if:

- Spindles are sharp and turning
- Excess oil and grease are cleaned from picking heads
- Moistener pads and doffer columns are in good condition and properly adjusted
- Doffer lugs barely clear each spindle
- Pressure plates are adjusted according to crop condition
- Spindle cleaner used in moistening system where green leaves are present

- Picking units and baskets are cleaned and inspected at every dump
- Picking wet cotton or adding too much water is avoided
- Harvesting should be delayed until dew has dried, humidity is below 50%
- Seed cotton moisture is less than 12% (use a moisture meter or bite the seed, they should crack. This often means starting to pick around 10am or later)
- Seed cotton is kept dry during handling and storage. If cotton is wet, keep it separate from dry cotton and advise the ginner to see if it can be ginned early.

For stripper harvest, the last four points above also apply along with the following:

- Ensure that the crop is adequately defoliated / desiccated
- The stripper is fitted with an efficient pre-cleaner

Preparation

Preparation relates to the evenness and orientation of the lint in the sample. Factors contributing to poor preparation include spindle twist or wrapping during picking and roping or knotting (neps) of immature or very fine fibres in the ginning process.

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 on a "beard" or tuft of lint formed by grasping fibres with a clamp. Fibre length is controlled to a large degree by variety, although weather and management can also influence it. Maximum fibre length is determined during the fibre elongation phase in the first 20 days after flowering.

During elongation length is decreased by high temperatures, very severe water stress and potassium deficiency. It is increased by moderate temperatures during that same period. Under raingrown conditions, staple length tends to range from similar to irrigated cotton (1 3/32 inches) down to very short (1 inch or less). It is wise to apply a staple discount of up to 1/16 inch for budgeting purposes in raingrown cotton. Ginning and lint cleaning can also reduce length if lint moisture is below 5%, but this seldom occurs because moisture is usually added to seed cotton in this condition to allow better flow through the gin.

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 variety, 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 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 as shown in **Table 46**.

Table 46: Micronaire Discounts.

Group	Micronaire	Discount US$/Bale	Price US$/Bale
G7	5.3 and above	-20.00 - 35.00	315.00 - 330.00
G6	5.0 - 5.2	-12.00 - 30.00	320.00 - 337.00
G5	3.5 - 4.9	Base	350.00
G4	3.3 - 3.4	-20.00 - 35.00	315.00 - 330.00
G3	3.0 - 3.2	-50.00 - 63.00	287.00 - 300.00
G2	2.7 - 2.9	-73.00 - 100.00	250.00 - 277.00
G1	2.5 - 2.6	-95.00 – 115.00	235.00 - 255.00
G0	2.4 and below	-140.00 - 175.00	175.00 - 210.00

Fibre thickening develops after the elongation phase and continues until mature according to carbohydrate supply. Hence, growing conditions which influence growth and maturity in the finishing stages of the crop will affect fibre thickening and micronaire. Insufficient carbohydrate to meet boll demand results in low micronaire whilst ample carbohydrate to mature bolls results in high micronaire.

Common causes of low micronaire include:

- cool temperature during fibre wall development
- potassium deficiency
- dense plant stands
- high nitrogen
- excess irrigation / rainfall
- favourable fruit set and high boll retention
- 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
- Variety

Ginning has little or no effect on micronaire although low micronaire cotton is more susceptible to entanglement and nepping which can affect preparation and subsequently grade.

Raingrown cotton normally falls into the acceptable micronaire range, 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. Boll filling ceases within 5 days of defoliation, so early defoliation must be avoided.

Fibre strength is important in determining price if it is below 24GMS/TEX when a discount of the order of US$15.00/bale will apply and US$5.00/bale for strength between 25 to 27g/tex. There is no premium for high strength although it is an important element in marketing.

Fibre Strength

Fibre strength is highly controlled 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.

It 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)

More than 30 very strong

Other Quality Characteristics

A number of other fibre characteristics measured in HVI testing which, whilst of increasing importance to spinners, does not have a direct impact on price at present. Further detail on these is available from cotton classers and they include:

- Upper Half Mean Length (UHM)
- Span Length
- Uniformity Index (UI)
- Uniformity Ratio (UR)
- Elongation (EL)
- Short Fibre Index (SFI)
- Maturity
- Fineness
- Sugars (honeydew)
- Nep

COTTON GRADE AND PRICE

The effect of a range of grades on the price of a bale of cotton (quoted in US$) is set out in **Table 47** for G5 micronaire. Note that the premiums and discounts do fluctuate throughout the season due to supply and demand and this is reflected in the price ranges given below.

SUMMARY

Although always classed on its merits, the price of raingrown cotton is more likely to be discounted than irrigated cotton. A number of the reasons for this have been given in this chapter such as: short staple, spotted grades and high micronaire from hot dry conditions; low micronaire from development of late bolls under cool conditions (i.e. late planting); and lower grades from extra trash gathered by stripper harvest. When setting budgets, raingrown growers should consider reducing quoted prices for base grades by US$20-50/bale to provide a more realistic estimate of their likely returns.

Table 47: Premiums and discounts for a range of grades and staple lengths.

Grade	Premium/Discount US$/bale	Price US$/bale	Comment
21-2 35	+3.00 - 7.00	353.00 - 357.00	Higher grade
31-3 35	Base Grade	$350-00	Base price
21-2 33	-37.00 - 60.00	290.00 - 313.00	Higher grade, shorter staple
31-4 35	-10.00 - 20.00	330.00 - 340.00	Lower leaf
31-4 33	-37.00 - 60.00	290.00 - 313.00	Lower leaf, short staple
41-2 35	-27.00 - 55.00	295.00 - 323.00	Discoloured
41-2 33	-55.00 - 75.00	275.00 - 295.00	Discoloured, short staple
51-5 35	-55.00 - 80.00	270.00 - 295.00	Low grade
51-5 33	-75.00 - 140.00	210.00 - 295.00	Low grade, short staple

By Kim Morison, Colly Cotton

KEY POINTS:

- **Sell crop in Australian dollars (don't speculate in foreign exchange or the futures market)**
- **Consider area (acreage) pool contracts with a reputable pool manager**
- **Don't sell something you haven't got. (ie. Don't forward sell)**

Marketing Alternatives for Dryland Producers

To achieve successful and profitable dryland cotton production, growers must be prepared to manage the marketing of their production.

The main aim of this section is to present the important features of the marketing alternatives available to cotton growers. To fully understand the alternatives it is necessary to understand the marketing risks and risk management tools involved.

This section is not intended to be a “Do It Yourself” marketing kit, rather it serves to introduce a range of concepts and terms with which you will encounter in marketing your crop successfully. All growers should seek advice on marketing matters from cotton marketing companies and/or consultants with proven records in their fields of expertise. It also helps to talk to established cotton growers to share their experience.

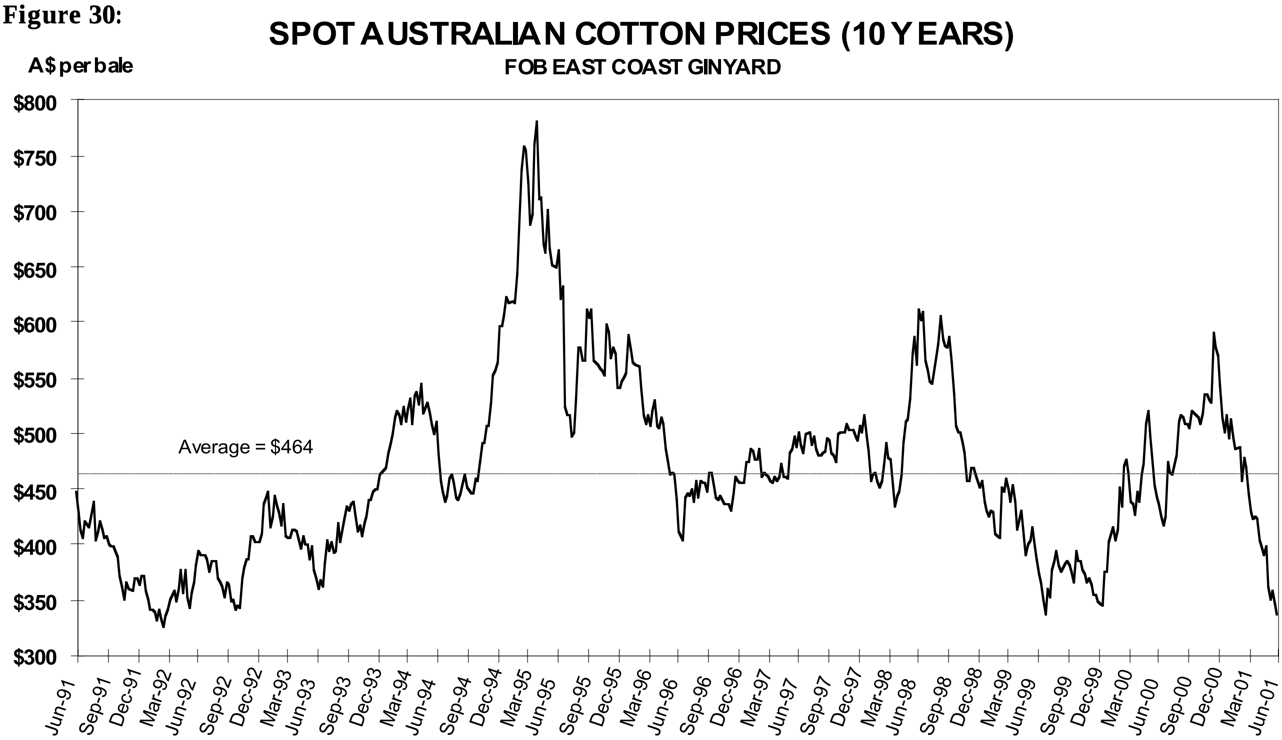
BACKGROUND

As shown in **Figure 30** the Australian dollar price per bale of cotton fluctuates considerably. The Australian dollar price changes on a daily basis depending on movements in the underlying international cotton price and movements in the Australian dollar exchange rate.

Annual and short-term price fluctuations can create major uncertainties or risks for cotton growers when deciding whether to plant cotton and when to sell. In addition, growers face the inconsistencies of seasonal conditions and the complexities of successfully growing cotton. The uncertainties of seasonal conditions are particularly important for dryland cotton growers.

If all those uncertainties, were not enough, new growers can also be daunted by the wide range of marketing alternatives now available from a wide range of buyers. However if properly used, these alternatives and the price competition available each day can work to the growers’ advantage.

Figure 30:



For many years now the Australian cotton market has benefited from an active forward market. For growers this involves the use of marketing alternatives to fix or lock in a price on all or part of the expected crop before the cotton has been harvested. The ability to lock in returns before harvest can be a major advantage for some growers, because of the large investment needed to grow and harvest cotton. However, fixing prices before harvest may also be risky, especially if production levels are uncertain. These and other marketing risks are examined briefly in the next section.

MARKETING RISKS

Marketing for a cotton grower is largely a question of managing production and price risks. These risks are not only complex, but personal, and vary from situation to situation and over time. Growers need a clear understanding of these risks and how they relate to their operations before making marketing decisions.

Production risks broadly relate to quantity (yield and area) and quality.

Quantity risk is the possibility that production may differ significantly from original expectations. This is particularly so for dryland cotton production. If a grower enters into a contract to supply cotton at a future date before the crop is planted, there is uncertainty about the area to be planted (because of seasonal conditions) and the level of yield that will be obtained from the area actually planted. If a contract is entered into after planting, the yield risk still exists.

There is also the risk that the **quality** will not be as expected as a result of seasonal conditions, pests, diseases, poor management practices etc. Typically cotton sold forward is sold on a **base grade** description of USDA standard Middling grade, 1 3/32 inch staple length, micronaire in the range of 3.5-4.9. Once the cotton is ginned it is then classed and the final price to the grower is adjusted by a premium or discount depending on the actual quality compared to the base grade.

Price risks broadly relate to the international price of cotton and the exchange rate to convert the international price into Australian dollars.

Over 95% of the Australian cotton crop is exported each year. Therefore Australian domestic cotton prices reflect the international price of lint cotton, which is traditionally traded in US cents per pound.

The international benchmark for cotton price discovery is the New York Board of Trade cotton **futures** contract. The NYBOT futures market trades the price of US cotton for delivery in the months of March, May, July, October and December each year going forward for 18 months.

Australian cotton merchants use the NYBOT cotton futures contract to hedge their exposures in trading Australian cotton. As such, changes in the futures price for May and July futures in particular usually have a high correlation with Australian cotton prices each day.

Figure 31: NYBOT SPOT COTTON FUTURES (10 YEARS)

The futures market trades the price of US cotton delivered to US warehouses. As such there are some adjustments required to equate Australian cotton price to daily changes in NYBOT futures prices. The difference between Australian cash prices expressed in US cents per pound and the May or July futures price on any one day is commonly known as the **basis**.

The basis may be broadly defined as the premium or discount to the New York futures price for cotton being sold at any point in time at any particular location. The basis generally takes account of differences in quality and transport costs between New York and the place where the cotton is being delivered.

Generally, Australian growers are only interested in revenue in Australian dollars. As the majority of Australian cotton is exported, Australian growers do face price risks associated with the exchange rate from US dollars to Australian dollars. This risk should not be underestimated, as it plays a major part in influencing returns.

The extent to which the NYBOT futures price and the AUD / USD exchange rate fluctuate are shown in **Figures 31 and 32**. Each shows the weekly change in prices over the last 10 years.

Cash prices for cotton at the gin-yard in Australia are a product of New York futures, the basis and the Australian dollar exchange rate. 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.

Although production and price risks have been treated separately in this article, the link between the two cannot be over-emphasised. For example, if a grower decides to enter into a contract (either before or after planting) to sell a specified quantity of cotton at a specified time for a fixed price this results in exposure to several risks.

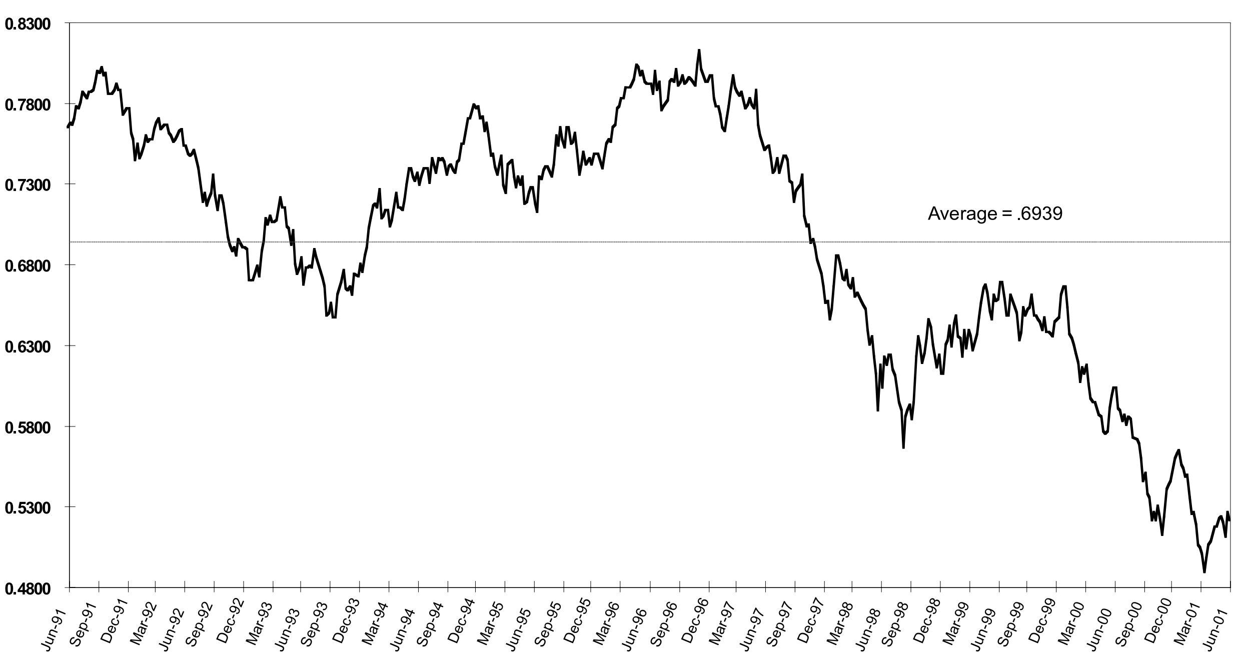
One risk, or opportunity cost, is that if the grower had waited and actually sold the crop later, a higher price may have been achieved. Another is that not enough cotton may be produced to meet the contract requirement. In this instance, if prices go up, then the grower has to go out in the market and buy at a higher price to replace the shortfall. This inevitably reduces returns (sometimes considerably). Of course, the opposite risk of prices falling and production being greater than expected must also be considered.

MARKETING ALTERNATIVES

The Australian cotton market is well serviced by a range of cotton merchants and marketing co-operatives. Each marketing organisation competes daily to buy cotton from growers and sell into the international market.

Some of the marketing organisations have their own gins and can arrange both ginning and marketing services for the grower. In general however, marketing and ginning tend to be viewed as independent operations and it is the growers responsibility to have the cotton ginned ready for sale or delivery against existing contracts.

Figure 32: **AUSTRALIAN DOLLAR (10 YEARS)**



The names used by merchants to describe their marketing alternatives differ somewhat and so to do the detailed terms and conditions associated with their alternatives. Growers should therefore check the details of each merchant's alternatives carefully. The most appropriate alternative or combination of alternatives will be determined by many factors including individual circumstances and market conditions.

The marketing alternatives available from most merchants have been examined and are summarised below.

1. Fixed Priced Contracts

Fixed prices contracts may be entered into before or after the cotton has been harvested.

Forward contracts are simply agreements between buyers and sellers to trade specified amounts of a specific commodity at a specified time for a specific price. All marketing organisations in Australia offer forward price contracts. These contracts may be for a fixed number of bales, or may specify all bales produced from a specific area of cotton planted.

Under a **fixed bale forward price contract**, the merchant agrees to pay the grower a fixed price for a fixed number of bales. The contracted quantity must be delivered to the merchant, however there are usually clauses in each contract to cover a non-delivery event.

The financial advantage of fixed price contract is that the final price for base grade cotton is known when the contract is made. Payment is typically made within 14 days of ginning or classing of the cotton.

Payment for cotton can also usually be arranged in Australian dollars or US dollars per bale.

Some merchants offer **area or yield risk contracts** that do not require the grower to supply a specified quantity. In such cases, the merchant expects the grower to supply all the cotton from the particular area contracted.

All merchants also offer fixed bale cash price contracts for cotton that has already been ginned and classed. These can often be known as **spot price contracts**, for cotton for immediate delivery, or on the spot.

2. Pool Contracts

The pooling concept is well known to grain growers and is also used by many cotton growers. The main features of pools are:

- The individual grower's cotton is marketed together with that of other growers in a pool.
- The pool manager markets the pooled cotton using a variety of marketing methods over the season.
- The growers receive an equalised net return adjusted for the quality of each delivery made to the pool.

The pool manager is responsible for managing the price risk of the cotton in the pool.

In most instances the grower has to contract to deliver to a specific pool. The grower must nominate in advance the area or quantity of bales which is going to be delivered to the pool. For **fixed bale pools** there may or may not be penalties for no-delivery. For **area or yield risk pools** there are usually clauses which pass the yield risk to the pool manager and exclude penalties for non-delivery caused by crop failure, low yield, hail and flood events etc.

Area pools have two advantages for growers. First, the price risk exposure is managed by experts in the industry and second, the yield risk is reduced for the grower. Perhaps one of the disadvantages of the pool system is that the final return to the growers is not known until the pool is finalised. The final return will depend on the total number of bales delivered to the pool, the sales and hedging strategies used by the pool manager, and the costs associated with delivering all bales to their final end user markets. During the season most organisations operating pools estimate what the final pool return will be on a regular basis. Payments for pools are usually made over several months coinciding with the shipment of bales to their final destination. The sales and shipment period can stretch out until March in the year following ginning.

3. On-Call Contracts

As we have outlined, the price of Australian cotton is determined by three price variables: futures, basis and the AUD/USD exchange rate. Under an **on-call contract** the grower is entitled to call on the merchant to hedge each individual price leg at different times, hopefully coinciding with the optimum level for each price element. The main features are:

- The grower must undertake to deliver a certain quantity of cotton at a certain time
- The grower can decide at any time prior to specific contracted dates to lock in a price

- via the New York futures market price, the AUD / USD exchange rate and the basis for Australian cotton
- All three price legs must be fixed prior to final payment

Some merchants offer the grower an average basis achieved over the season that is then combined with the grower's fixed futures price and exchange rate.

The main advantage of an on-call contract is the ability for the grower to price different price elements at the most advantageous times with the aim of achieving optimum prices.

4. Guaranteed Minimum Price Contracts or Pools

These contracts are a variation on the fixed price or pool contracts. Under a Guaranteed Minimum Price (GMP) contract, the merchant will guarantee a minimum price for the contract. Normally, the grower is required to supply a fixed number of bales. These contracts are mainly based on the use of **options** (see below) to allow the merchant to guarantee a minimum price. The GMP alternatives are usually priced at a discount to the fixed price contracts. The advantage of the GMP contract is that it will allow the grower some participation in upward price movements after the contract has been agreed.

PRICE RISK MANAGEMENT TOOLS

Independent Hedging

All of the alternatives covered above involve a contract to a merchant to sell cotton, but growers may also hedge independently using futures contracts, forward currency contracts and options organised through their marketing organisation or merchant, or through other futures brokers and banks. The actual sale of the cotton to a merchant is still necessary at some point in time, however the underlying price of futures and the exchange rate can be hedged independently.

As mentioned, Australian cotton merchants use the NYBOT futures market to hedge Australian cotton price exposures. Growers can also use this market independently, but it is not recommended unless you have a thorough understanding of the operation of the market and the risks and costs involved.

Futures hedging is complex and is considered beyond the scope of this manual. However, one of the more advantageous tools that can be used to hedge price exposures for a grower is through the use of options on futures contracts and options on the AUD / USD exchange rate so we will include a brief explanation here.

A futures *option* is the right, but not the obligation, to buy or sell a futures contract for a particular price and delivery month. For this right, the buyer or the seller pays or receives a premium. Options can be a very useful and flexible risk management tool for the grower. For example, options can be used to allow growers who have not forward priced their cotton, to insure or guarantee a futures market price; enhance forward sold cotton in a favourable moving market; or even to ensure futures prices without production risk.

MAKING THE DECISION

Despite the wide range of marketing alternatives available to growers, the choice of suitable alternatives is influenced by many factors. In the case of dryland producers, who face greater production uncertainty than irrigated growers, some marketing alternatives may not be available.

New dryland growers, in particular, should be conscious of the likely high risk of their production not being as planned, and should be very cautious in their attitude towards price risk management. They may well be best advised to consider using area or yield risk pools in order to hedge price and yield exposures.

When deciding how and when to use the range of available marketing alternatives, the following key issues should be addressed and understood before making decisions.

Marketing policy and strategies

All growers should have a clear marketing policy and strategies in place to achieve their objectives. Even if this just involves selling through a seasonal pool, the reasons for this strategy should be known and the forecast price should be assessed relative to other alternatives.

Seeking advice

Because marketing can be so complex, growers should seek advice from marketers and consultants with proven track records, and also to seek the advice – and benefit from – the experience, of other growers. Growers should also look carefully at the results of using particular marketing methods / hedging strategies in previous years.

Tax considerations

Growers should consult their tax adviser before setting a marketing strategy. Pools are generally finalised, and therefore pay the majority of income, in the financial year following ginning, which enables the grower to declare this income in that fiscal year. Cash contracts are usually paid 10-14 days after ginning. Consequently this may be assessed as taxable income in the year of harvest/ginning.

Module and bale loans

Most merchants offer the growers a payment advance or loan on cotton in a module form and waiting to be ginned. This gives the grower some cash flow around harvest time as cotton lint payment may be delayed while the cotton waits to be ginned or the cotton is sold into a pool.

Taking account of all risks

Both production and price risks are very real to cotton growers. Either may cause financial losses and therefore the risks should not be underestimated. Given their total reliance on seasonal conditions, dryland growers should view production risk as critical in their planning. Also, when looking at the price risk, growers should be careful to take account of both the commodity price and the exchange rate.

Understanding financial implications

Growers should fully understand the financial implications of the marketing alternatives available to them. As outlined above, these can vary enormously.

Understanding terms and conditions

All terms and conditions of any marketing contract should be fully understood before the contract is signed. In signing a contract, growers should bear in mind the substantial differences which often exist between contracts offered by difference merchants.

Maintaining close contact with the merchant

Having entered into a contract with a merchant, the grower should maintain close contact with that merchant throughout the season. If things do not go as expected in terms of production or market prices it may be possible for the merchant to recommend some solutions to the resulting problems which would not be immediately apparent to the grower.

Monitor and review

Growers should continually monitor, review and, where necessary, revise their marketing policy and strategies during and after a marketing season.

MARKETING GLOSSARY

At the money
An option contract whose strike price is the same as the current price for the underlying futures contract is said to be 'at the money'.

Average Basis Pool
The grower nominates a set number of bales in 100 bale lots (100bales = 1 contract) and accepts the average basis of all bales sold within this pool. The advantage of this basis is that 'force majeure' usually operates. The disadvantage is that the grower does not know the value of the basis until the merchant has set the basis on all the bales in this pool.

Basis
Difference between the price in a particular cash market and the nearby futures price.

Basis forward contract
Forward contract in which the sale price is set at a fixed margin with respect to a particular futures price.

Call Option
Option to buy futures contract at a specified price - the strike price - prior to a specified date. the futures contract concerned would confer (in principle) future receipt of the commodity.

Call pool
Delivery alternative for Australian cotton growers whereby they commit a quantity of cotton to a particular marketing organisation, while retaining the freedom to hedge using futures and options. Each grower can choose when to 'lock in' (in effect, ensure receipt of) the then quoted May or July US futures price, and likewise when to 'lock in' the Australian basis and the rate of exchange of US dollars into Australian dollars.

Cash market (spot market)
Market in which immediate exchange of the physical commodity takes place. Payment for the commodity is received on or soon after the day of exchange.

Clearing house
Institution through which all futures contracts are made, and are either 'closed out' or are fulfilled by physical delivery of the commodity after matching purchases with sales. It operates a system of margin payments to ensure the integrity of futures and option contracts.

Cotlook A index
Average quotation for middling $1\frac{3}{32}$ inch cotton, including freight to northern European ports. Cash price for cotton from twelve different countries or areas are used to form this index, which is defined as the average of the lowest 5 of the 12 prices.

Extrinsic ('time') value (of an option contract)
A component of an option premium that reflects the probability that the price of the underlying futures contract will change to a level at which it is profitable for the holder to exercise the option.

Fixed price forward contract
Forward contract in which a certain price (as distinct from a formula for a variable price) is established at the time the contract is signed.

Fixed Basis Pool
The grower nominates a set number of bales in 100 bale lots. When the grower is confident of producing the quantity committed to this pool, they will agree on a fixed basis with their merchant. The advantage of this is that the grower knows the exact price of the basis to calculate their return per bale. The disadvantage, particularly for dryland growers, is that 'force majeure' does not apply and therefore the grower has an obligation to deliver the physical bales.

Force majeure
'Act of God' such as drought, which is accepted as excusing fulfilment of a contract.

Forward contract
A binding contract specifying the price (or price formula such as basis), quantity and quality of a product to be delivered at some specified date. The quantity may be expressed in units of output or as the production from a specified area.

Forward exchange rate
Rate of exchange between two countries' currencies which is contracted to be applied at some time in the future.

Forward points
Difference between the currently quoted forward exchange rate and the current spot exchange rate, in hundredths of a cent.

Futures contract
A legally binding document requiring, at a standard date, either delivery or acceptance of a given quantity (50,000lbs, in the case of cotton) and quality of a commodity. It is, in effect, a forward contract in which the main elements have been standardised for all traders. Only the price for a transfer of the 'contract' itself is negotiated. The current price of a futures contract determines the current futures price of the commodity. A contract to deliver can be 'closed out' by buying a futures contract to take delivery; and vice versa.

Futures price
The price agreed by open competition, at any given time, for a commodity which will be delivered on a specified month. There is a fixed set of months for this purpose (March, May, July and December in the case of cotton), and a fixed set of delivery points. For cotton, futures prices are established at the New York Cotton Exchange.

Hedging
Process of reducing risk by arranging transactions with counterbalancing risks in a number of different markets.

In the money
An option contract is said to be ' in the money' when its strike price is at a level in relation to the current price for the underlying futures contract such that it would be profitable to exercise the option.

Intrinsic value
Value, if any, that an option would have if exercised at the present time; the difference between the current price of the underlying future contract and the option strike price.

Long
The purchaser of a futures or option contract is said to take a long position. In the case of a futures contract, 'long' denotes, in principle, ownership of a commodity. In the case of an option, it simply denotes possession of the option, regardless of whether the option is to buy or to sell.

Margin call
Payment that the holder of a futures (margin payment) contract (either for acceptance or delivery) must make to the clearing house if the future price moves in a direction adverse to the holder.

Nearby future prices
At any point in time the future price for the next in the series of fixed delivery dates.

Option contract (option on futures)
Conditional contract to buy or sell (see call,put) a futures contract at a specified strike price. The option is exercised only if and when the option holder so decides. It is available only up to a specified date.

Option Premium
Payment by the buyer of an option contract to the seller of that contract. The premium can be considered as consisting of the two components: the intrinsic value and the extrinsic (or time) value.

Out of the money
An option contract is said to be 'out of the money' when its strike price is at a level in relation to the current price for the underlying futures contract such that it would not be profitable to exercise the option.

Put option
Option to sell a futures contract at a specified price - the strike price- prior to a specified date. The future contract concern requires (in principle) future delivery of the commodity.

Seasonal pool
Delivery alternative for Australian cotton growers whereby they commit either a specified quantity of cotton or the production from a specified area to a particular marketing organisation. Each grower who delivers to this pool subsequently receives the average price the organisation obtains for all the cotton delivered to the pool during the same season (with adjustments to reflect quality differences)

Short
The seller of a futures or option contract is said to take a short position. In the case of a futures contract 'short' denotes an obligation, in principle, to supply a commodity. In the case of an option, it simply denotes being subject to the purchaser's right to exercise the option, regardless of whether the option is to buy or sell.

Spot exchange rate
The current rate for immediate exchange between two countries' currencies.

Spot market
See cash market.

Strike price
The specified price at which the holder of an option contract can sell the underlying futures contract - in the case of a call option.

ACRONYMS

In the interests of readability and ease of use, the Corporation attempts to avoid acronyms, initialisms and those abbreviations that are not self-explanatory wherever possible. However, some times it is unavoidable. Following is a list of acronyms that are used in the cotton industry or by Government, and/or that may appear in this publication.

AAAA	Aerial Agricultural Association of Australia
ABARE	Australian Bureau of Agricultural and Resource Economics
ACEC	Australian Cotton Exhibition Centre
ACGRA	Australian Cotton Growers' Research Association
ACIC	Australian Cotton Industry Council
ACRI	Australian Cotton Research Institute (located near Narrabri, NSW)
ACSA	Australian Cotton Shippers Association
AFFA	Agriculture Fisheries and Forestry - Australia
ANAO	Australian National Audit Office
APSA	Australian Planting Seed Association
ARLP	Australian Rural Leadership Program
ARRIP	Australian Agricultural Research in Progress database
AWA	Agriculture Western Australia
AWiA	Australian Women in Agriculture
AWM	Area Wide Management
BMP	Best Management Practices
Bt	Bacillus thuringiensis (crystal protein expressed in INGARD® Cotton)
CA	Cotton Australia
CAPA	Cotton Agricultural Products Assocation
CCA	Cotton Consultants Australia Inc.
CGA	Cotton Growers' Association
CGS	Cotton Growers' Services
CIE	Centre for International Economics
Cotton CRC	Australian Cotton Cooperative Research Centre
CQ	Central Queensland
CRC	See ACCRC
CRDC	Cotton Research and Development Corporation
CSD	Cotton Seed Distributors
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DA	District Agronomist
DPA	DeltaPine Australia
DLWC	Department of Land and Water Conservation (NSW)
DNR	Department of Natural Resources and Mines (Queensland)
DPIF	Department of Primary Industries and Fisheries (NT)
EPA	Environmental Protection Agency (NSW)
GMAC	Genetic Manipulation Advisory Committee
GROA	Groundrig Operators Association
ICAC	International Cotton Advisory Committee
IDO	Industry Development Officer
IP	Intellectual Property
IPM	Integrated Pest Management
L&WA	Land & Water Australia
MDBC	Murray Darling Basin Commission
NRA	National Registration Authority
NSW Ag	New South Wales Agriculture (Department of)
QC	Queensland Cotton
QDPI	Queensland Department of Primary Industries
RCMAC	Raw Cotton Marketing Advisory Committee
RRDC	Rural Research and Development Corporations
TIMS	Transgenic and Insect Management Strategy committee
TRC	Technology Resource Centre (Australian Cotton CRC)

USEFUL WEBSITES

SOME USEFUL WEBSITES IN THE COTTON INDUSTRY

Australian Cotton Co-Operative Research Centre
www.cotton.crc.org.au

Bureau of Meteorology
www.bom.gov.au

Cotton Australia
www.cottonaustralia.com.au

Cotton Consultants Australia
www.cottonconsultants.com.au

Cotton growers website
www.ozcotton.net

Cotton pests and diseases
http://ipm.ncsu.edu/cotton/InsectCorner/photos.htm

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

Cotton Seed Distributors
www.csd.net.au

Cotton World
www.cottonworld.com.au

CSIRO
www.csiro.au

Deltapine Australia
www.deltapine.com.au

Farmshed Weekly, The
www.thefarmshed.com.au

NSW Dept of Agriculture
www.agric.nsw.gov.au

QLD Dept of Natural Resources
www.dnr.qld.gov.au/longpdk/

QLD Dept of Primary Industries
www.dpi.qld.gov.au

NOTES: