Vol 24, No 5, page 62 October–November, 2003

Dryland cotton: Balancing yield, quality and costs

By Michael Bange, Peter Carberry and John Marshall

Some useful rain in some areas and the opportunity for decent prices for cotton have again stimulated significant interest in dryland cotton.

One of the management techniques that dryland growers have at their disposal is being able to modify row configuration. Growers can use conventional solid row configurations or configurations that considerably increase row spacing or remove entire rows.

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

Choosing skip-row configurations over solid in soils with reasonably high soil water holding capacities and fertility may slightly reduce crop yields, but insure against significant financial penalties associated with poor fibre quality.

In some instances when fibre quality penalties are incurred, an extra 1.6 bales per hectare would need to be grown in the solid configuration to meet the costs of production compared with skip configurations. It emphasises that to optimise economic benefit in dryland cotton systems, both good crop yields and fibre quality need to be achieved concurrently.

But growers need not take uncalculated risks when considering dryland production. History and research can often serve as our best guide

FIGURE 1: Simulated yields versus observed yield for commercial dryland cotton crops with various row configurations in NSW and Queensland

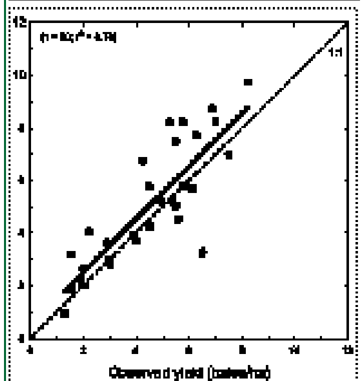
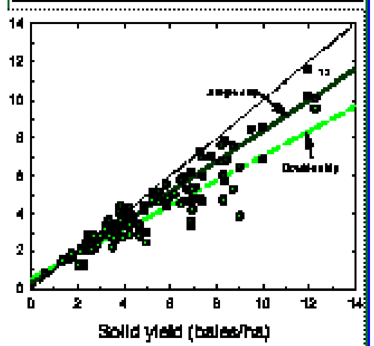


FIGURE 2: Relationships of skip row configurations yields relative to solid configuration yields from field studies in Central Queensland, Darling Downs and Narrabri



Data from Gayne (2000), Marshall et al. (1994), Pyke (1991) and Hearn (unpublished).

to the potential risks and benefits of different dryland cropping strategies.

We have used data from field experiments and the cotton crop simulation model OZCOT to explore the impact of row configuration on potential yield and fibre quality of dryland production. This article presents the information and the tools that are available to help growers choose appropriate row configurations and assess their potential for dryland cotton production.

The OZCOT model

The use of crop simulation models is a powerful way to explore different cropping scenarios without suffering the consequent pain and real life experience when misfortune strikes. The OZCOT model developed by Brian Hearn (CSIRO Plant Industry) is a dynamic simulation model of cotton growth, development and yield. It uses a daily time step with growth and development being driven by temperature and intercepted radiation.

Growth processes are modified by soil moisture and nitrogen status. In recent years the model has been used with growers to explore a range of issues in dryland cotton production including selecting row configurations, comparing cropping systems and the impacts of climate variability as part of the FARMSCAPE initiative led by the Agricultural Production Systems Research Unit (APSRU) based in Toowoomba. The cotton model in APSIM is the OZCOT cotton simulation model.

In exploring the use of simulation models for crop management as part of FARMSCAPE initiative, commercial dryland crops with various row configurations were monitored and yields measured. The crops were grown across southern Queensland and northern NSW production areas. Yields of these crops were compared with those predicted by the OZCOT simulation model. This process allowed growers to gain some confidence in the ability to use simulation technology to explore crop

TABLE 1: Estimates of potential yield (bales per hectare) using the OZCOT simulation model, for different row configurations (solid, single and double) for three starting soil moisture levels at sites in Queensland and northern NSW

Configuration/Region	One quarter of a full profile			One half of a full profile			Full profile		
Solid	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 Creek	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
Single									
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
Double									
Breeza	0.7	0.0	1.3	1.4	0.2	2.6	1.4	0.2	2.6
Wee Waa	2.3	0.6	4.0	3.9	2.8	5.2	4.0	2.9	5.3
Bellata	2.1	0.3	4.0	3.7	2.5	4.9	3.9	2.9	5.0
Moree	1.8	0.2	3.2	3.5	2.4	4.7	3.8	2.7	4.8
Croppa Ck	2.0	0.2	3.5	4.0	2.6	5.7	4.2	3.0	5.8
Goondiwindi	2.1	0.4	3.7	3.7	2.5	4.7	3.8	2.6	4.9
Dalby	2.6	0.9	4.4	3.8	2.7	5.0	3.7	2.6	5.0
Biloela	3.4	2.1	5.0	4.7	3.4	6.0	4.7	3.4	5.9
Emerald	3.0	0.9	4.8	4.4	3.0	5.7	4.6	3.3	5.8

*Variability of yields expressed in terms of the 'probability of exceedance'. This is the probability of exceeding the nominated yield for each region. For example, a crop at Breeza, planted solid on soil moisture of one quarter of a full profile has an 80% chance of yielding 0.4 bales per hectare or more and a 20% chance of yielding 2.7 bales per hectare or more.
The soil profile had a plant available water holding capacity of 200 mm

TABLE 2: Thresholds for discounts for fibre length and micronaire, and corresponding bale price reduction ($AUD per bale)*

Year	Fibre length (inches)				Micronaire	
	31/32	32/32	33/32	34/32	G4(< 3.5)	G6(> 4.9)
1996	$135	$95	$55	$20	$28	$30
2001	$165	$135	$103	$60	$50	$30

**Period 1996 versus 2001, discount averaged across merchants* management issues.

These tests confirmed that OZCOT was able to simulate commercial dryland cotton production well, accounting for 70 per cent of the observed variation across 30 crops (Figure 1). This degree of accuracy has been regarded as acceptable by growers, especially when the reasons for the few poor predictions were traced to non-optimal agronomy or insect control in the measured commercial crops.

During this time significant demand has developed from farmers and crop consultants for the use of simulation technology to benchmark performance of commercial crops and assess the risks associated with different crop management practices.

In using OZCOT to explore the potential yield of dryland production in this article we assumed the following generalised conditions based on current practices and typical soils:

• Cracking clay vertosol soil storing 200mm of available soil moisture in a 1.5 metre profile;

• Crops sown on October 15; row spacing set at one metre; and,

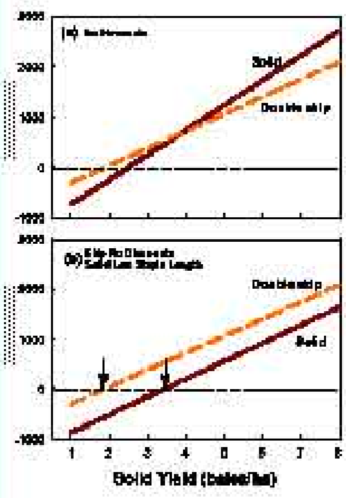
• An established population of seven plants per metre of row.

The model simulates potential yield of a typical variety. It does not account for the affects of insect pests, diseases, weeds, or soil nutrient limitations other than N. OZCOT was then run every year with the historical climate records available for each region.

Yield potential and row configuration

A number of field studies have been conducted to compare the relative yield of skip row configurations (single and double) compared with solid planted configurations. These studies generally show that when yields of solid configurations are high, there is a considerable yield penalty in using skip row configurations.

FIGURE 3: Economic comparisons of double skip and solid row configuration gross margins accounting for differences in costs and yield:
(a) No discounts for fibre quality;
(b) Discounts for low staple length



Assumptions used in the analysis are shown in Table 3. Based on studies conducted in Central Queensland, Darling Downs and Narrabri.

TABLE 3: Assumptions used in the economic comparison of solid and double row configurations to explore the relative impact of the combined differences in yield, costs of production and fibre quality

Item	$ Cost or Return
Variable costs	
Solid	$1236.07/ha
Double skip	$869.99/ha
Seed returns	$115/tonne
Lint returns	$450/bale
Gin outturn	37%
Staple discount (32/32)	$135/bale

But when yields of solid configurations are low, the difference in yield between skip row and solid configurations is negligible. When data from these studies are combined (Figure 2) the single skip row configurations yielded less than solid when the yield of solid was above 1.6 bales per hectare and double skip yielded less than solid when solid was above 1.5 bales per hectare.

These comparisons provide useful and generally consistent information that can allow growers to assess options based on their historic yield potentials. But their limitation is that they do not account for seasonal variation.

We used OZCOT to explore the long term variability in yield for the different systems. In Table 1, average simulated yield for the three different row configurations (solid, single and double) is presented for nine regional centres along with the ‘probability of exceedence’ values.

Probability of exceedence is used to indicate variability that exists with different climatic conditions experienced in each region. For example an 80 per cent probability of exceedence means that there is an 80 per cent chance of exceeding the nominated yield for the region.

Skip row plantings increased yields in a few years but reduced it in most. The result is that there is an overall reduction in mean yield for skip configurations, but the values of the 20 per cent percentile were generally increased by skip row production. That is, the risk of very low yields was reduced. In wet years there is enough water in the profile for solid configurations, so the extra soil storage capacity available to plants in skip configurations provides no advantage.

Often when significant yield advantages from skip row configurations are not found, fibre quality is often enhanced compared with solid configurations. The implications of this are now discussed.

Row configuration and fibre quality

Periods of insufficient soil water not only reduce the quantity of lint produced but also impact significantly on fibre characteristics. Seasonal temperature affects crop development and 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 and during boll filling. The use of skip row configurations provides some insurance against poor fibre quality at this time by providing a larger soil reserve available to the crop and so delaying moisture stress.

Severe water deficits during fibre elongation reduce fibre length and historically it is this characteristic that is most seriously affected in dryland cotton production. Achieving 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.

Micronaire is the other fibre quality trait that is often affected in dryland cotton production. The desirable fibre for cotton spinners lies in the micronaire range 3.8–4.5.

Low micronaire is likely to occur in crops that are continually stressed during boll filling. Conversely, 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.

Surplus photosynthate will be deposited in a reduced number of bolls, resulting in excessively thick fibres and a reduction in quality for spinning.

A considerable number of field trials showed that there were significant effects of row configuration on fibre quality. In these studies there were always fewer instances of fibre quality discounts in skip configurations compared with solid planted cotton. Instances of low micronaire were also more frequent in the solid row configuration treatments. Some instances of high micronaire were found in skip treatments.

Table 2 highlights the considerable discounts that can be incurred for fibre lengths below base grade, or micronaire either below or 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.

Consequently, given experimental results showing fewer instances of discountable quality in skip row configurations, consideration of fibre quality issues and their impact on economics of dryland production systems is an important component when choosing row configurations.

Economics of different row configurations for dryland cotton

Various economic analyses of cotton production using alternative row configurations which include costs of production have been provided by both the QDPI and NSW Department of Agriculture. In many cases there is some financial gain in using skip row configurations, not from increased yields, but by reducing variable costs.

But it is important to note 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 additional inter-row cultivation or herbicide sprays for weed control.

While superior gross margins from skip row cotton can be achieved due to savings in variable costs, additional gains (or reduced risk of losses) can be made by maintaining fibre quality through the extra soil water available for developing bolls. We explored the impact of the combined differences in yield, costs of production and fibre quality on gross margins of solid and double skip configurations for a single season.

We chose to compare solid and double skip as there are generally greater gains in fibre quality in double compared with single skip configurations, and the relative yield differences between solid and double are greater. To compare the relative differences in gross margins we used the relationship that compares the relative yield of double skip versus solid from the combined dataset collected all from field experiments (Figure 2).

Assumptions used in the analysis are presented in Table 3. The analysis also assumed that no adjustment for input costs was made when expected yields were likely to be low.

When no deductions for fibre quality were applied, the analysis showed that the gross margin for double skip was less than that of solid configurations when the potential yield of the solid crop was 3.8 bales per hectare or more (Figure 3a). The divergence in gross margins as potential yields for solid increased was mainly due to the differences in yield potential between solid and double skip configurations as for yield comparisons in Figure 2.

The intersection of the relationships for the two configurations occurred at a higher point because of the difference in production costs. But when a discount for low staple length was applied to the solid configuration, it had a significant effect on the gross margin compared with double skip (Figure 3b). At no point did the gross margin of the solid configuration exceed that of double skip. Additionally, an extra 1.6 bales per hectare would need to be grown in the solid configuration to meet the costs of production compared with double skip.

This analysis demonstrates the importance of considering quality aspects as well as yield and costs of production when choosing row configuration. But the risk of incurring discounts for fibre quality is unlikely to be constant across yield levels. We need more detailed experiments to examine this issue.

These analyses act only as a general guide to the potential yield and risks of dryland production and row configuration choices 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 assessing growers' specific conditions using their own soil type and costs.

Seasonal climate forecasts

Over the past 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 to some extent. Adjusting management in the light of probable future weather trends offers considerable opportunities for managers of agricultural systems.

Crop models can be linked with this climatic information 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 be associated with the Southern Oscillation Index (SOI) phase, a measure of the strength of the ENSO phenomenon, at some useful 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 anticipated seasonal conditions. Information of this nature has been used successfully with dryland cotton growers in southern Queensland to assist with their choice of row configuration (solid versus skip).

In future

Improvements currently being made to the OZCOT crop simulation model to encompass the effects of environment on fibre quality will add significant value to using the model to choose row configuration in dryland cotton systems.

For further information on issues relating to the dryland cotton production, obtain a copy of the Dryland cotton production guide from the Cotton CRC's Technology Resource Centre in Narrabri or download it off the Cotton CRC or CRDC websites.

http://cotton.crc.org.au/

http://www.crdc.com.au/

To gain access to accredited agronomists using the APSIM crop simulation model to assist with decisions for dryland cropping contact your local Landmark representative or Michael Castor and Associates (Goondiwind) or the FARMSCAPE website, http://www.farmscape.cse.csiro.au

1CSIRO Plant Industry, 2CSIRO Sustainable Ecosystems, 3Cotton Seed Distributors 4Australian Cotton Cooperative Research Centre.