CHAPTER 2

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# Dryland cotton

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

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

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

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

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

**FIGURE 1.**

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

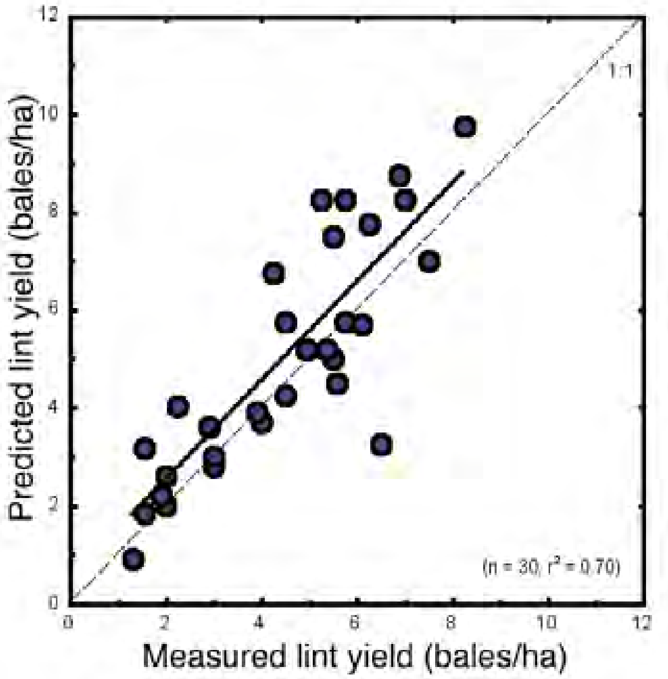
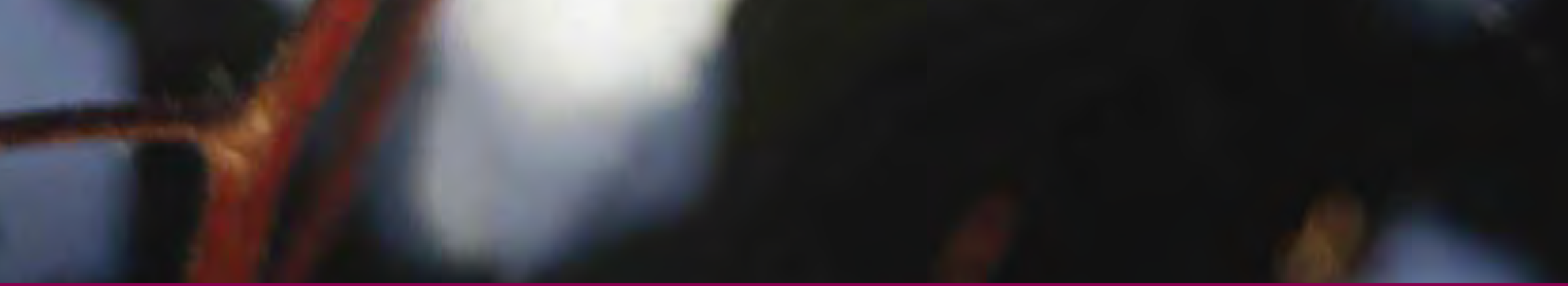



**TABLE 1.**

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

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



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

## Rainfall

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

## Predicting dryland cotton yield potential

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

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

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

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

### Sowing opportunities

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

A sowing opportunity was considered to occur when there was:

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

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

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

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

**TABLE 3.**
OZCOT predictions, *solid* row configuration – effects of two plant available soil water holding capacities on potential yield (bales/ha) and variability of yields, expressed in terms of probability of exceedence.

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

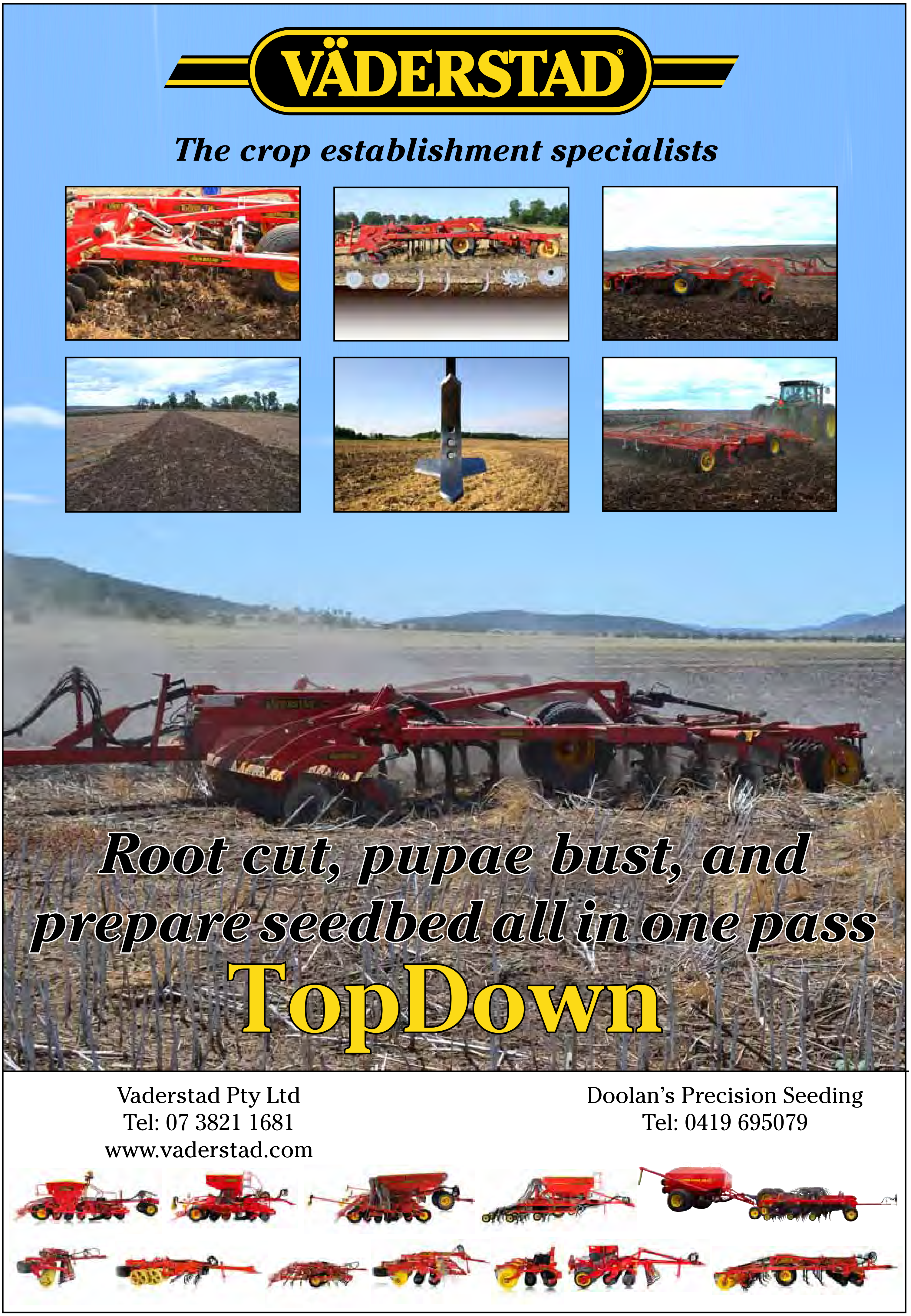
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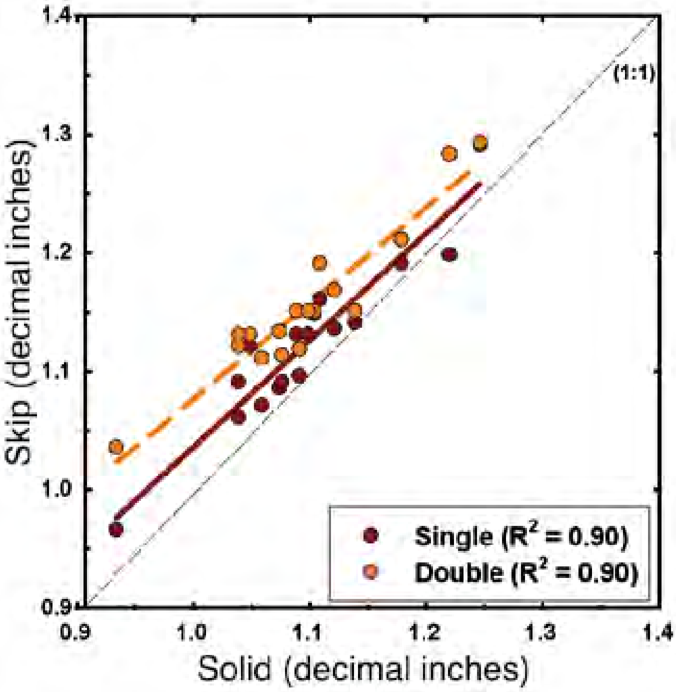
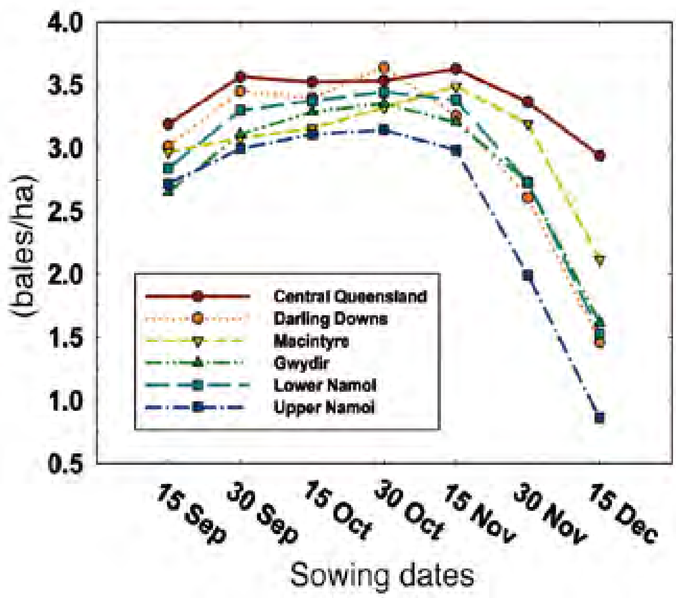
**FIGURE 2.**
Fibre length of skip row configurations compared with solid row configuration in dryland cotton systems. As points approach the 1:1 line, fibre length of the skip configurations equals that of the solid configuration (M. Bange, CSIRO). Note that this data is not simulated data.




## Dryland regional yield potential and row configuration

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

**FIGURE 3.**
Change in expected mean crop yield with sowing date. Yields have been predicted using a single skip configuration and plant available water holding capacity of 200mm.




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

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

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

### Time of sowing

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

**TABLE 4.**
OZCOT predictions, *single skip* row configuration – effects of two plant available soil water holding capacities on potential yield (bales/ha) and variability of yields, expressed in terms of probability of exceedence.

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

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

## Seasonal climate forecasts to assess risk

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

A useful way of interpreting seasonal forecasts is by identifying similar years in the climate history for the site of interest. Seasonal patterns in 'similar' seasons can be used as a guide for the potential risks and outcomes for the seasonal forecast. Outcomes of management decisions can then be assessed in terms of rainfall probability, average yields and the risks associated in achieving these yields for the coming season. While there are a number of ways of grouping similar years, one of the most successful approaches for partitioning historical records has been using the Southern Oscillation Index (SOI). The SOI is an index of the difference in atmospheric pressure between Darwin and Tahiti. It is a key indicator of the El Niño – Southern Oscillation (ENSO) phenomena. At present, we divide seasons into five groups, depending on the value and the rate of change of the SOI (SOI phase) at the time of forecast. The SOI phase is derived from the change in the SOI from last month to the SOI value at the time of the forecast. Phase I – SOI is consistently negative; phase II – SOI is consistently positive; phase III – SOI shows a rapid fall; phase IV – SOI shows a rapid rise; phase V – SOI is consistently near zero. Every month of the past 120 years has been categorised into one of the five phases that takes into account the value and change in SOI.

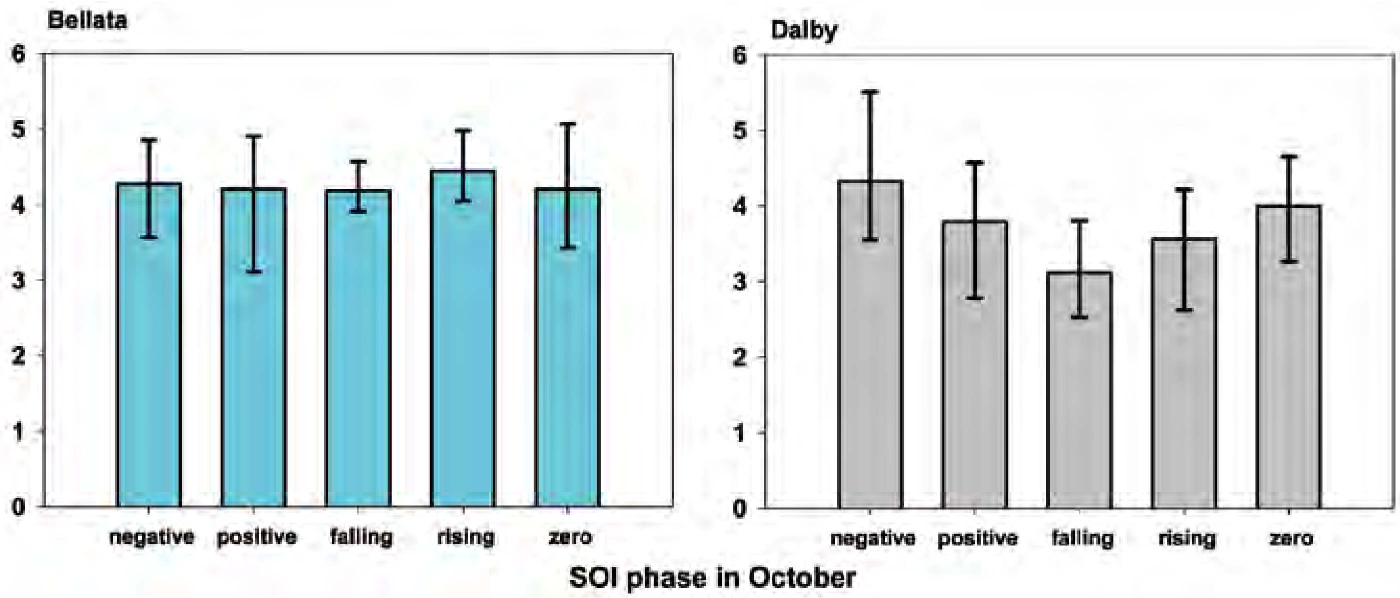
**TABLE 5.**
OZCOT predictions, *double skip* row configuration – effects of two plant available soil water holding capacities on potential yield (bales/ha) and variability of yields, expressed in terms of probability of exceedence.

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

**TABLE 6.**
OZCOT predictions, *single skip* row configuration – effects of sowing date on potential yield (bales/ha) and variability of yields, expressed in terms of probability of exceedence.

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

**FIGURE 4.**
Forecasted average dryland cotton lint yields (simulated using OZCOT using the details previous page for a 250mm plant available soil water profile) for single skip row configurations at Bellata (NSW) and Dalby (Qld) across for different phases of the SOI in October. The bottom of the error bar is the 80% probability of exceedence, while the top is the 20% probability. For a 200mm plant available soil water profile, average yields are less than for a 250mm profile and there is considerable more variability estimated for the negative, positive and zero phases. Average yields are considerably less for the rapidly falling and rising phases, but have less variability.




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

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

## Conclusions

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

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

**Sources of information:**

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

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

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

**The Bureau of Meteorology is Australia's national weather, climate and water agency, providing regular climate forecasts, warnings, monitoring and advice – www.bom.gov.au**

**Reference**

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