DRYLAND COTTON POTENTIAL & RISK

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KEY POINTS:

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

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**).

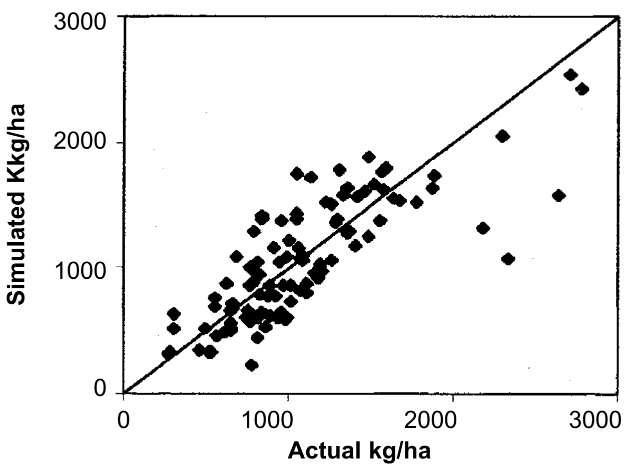

Figure 2: Simulated yield using the OZCOT crop simulation model versus actual crop yields from dryland cotton experiments exploring row configuration (R2 = 0.64). Data provided to Brian Hearn by Bruce Pyke and Phil Goyne.

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**).

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)	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.

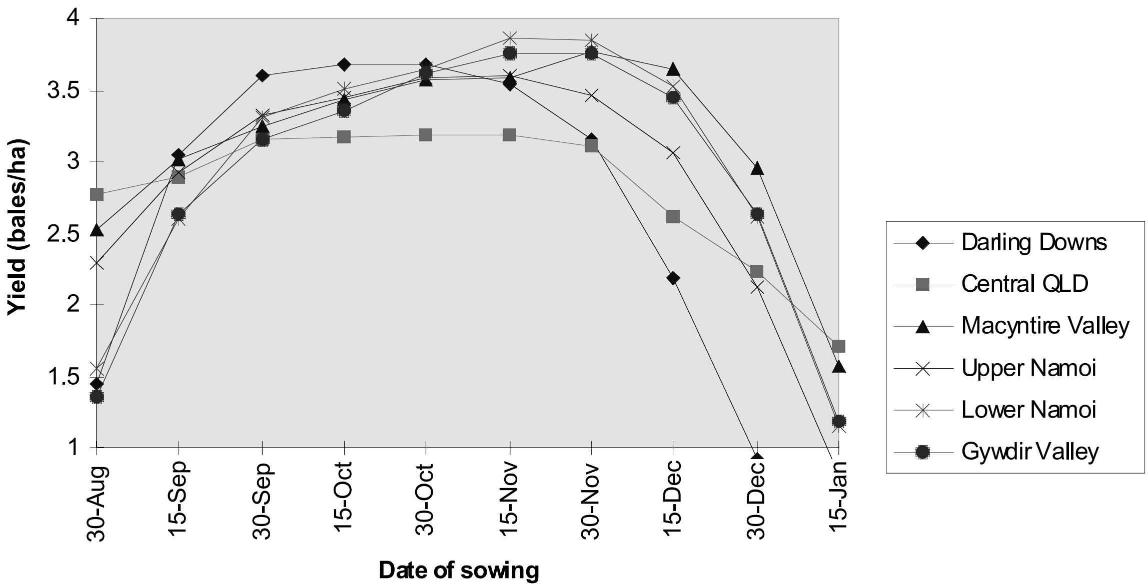

Figure 3: Change in expected crop yield with sowing date. Yields have been simulated using a typical commercial nitrogen rate for each region.

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

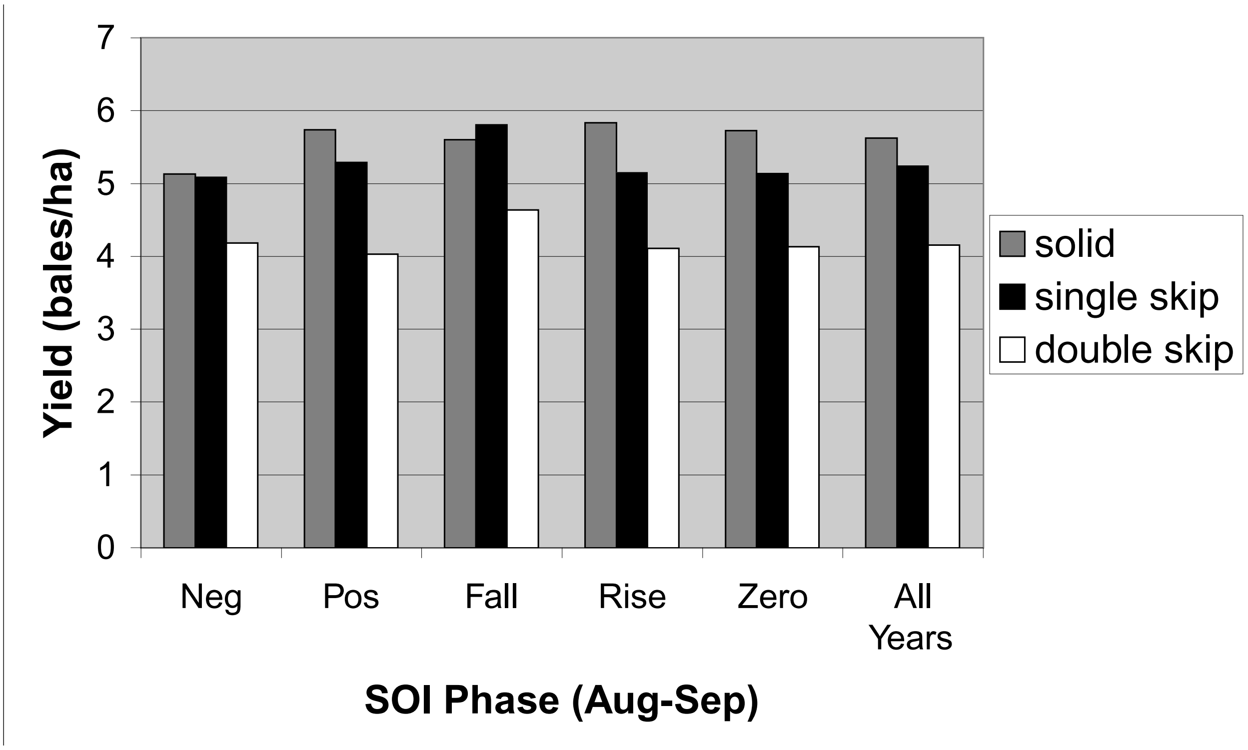

Figure 4: Forecasted average dryland cotton yields (simulated using OZCOT) at sowing time (October) for different row configurations with half a profile of soil moisture at sowing in Dalby for different phases of the SOI (Aug-Sep).

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

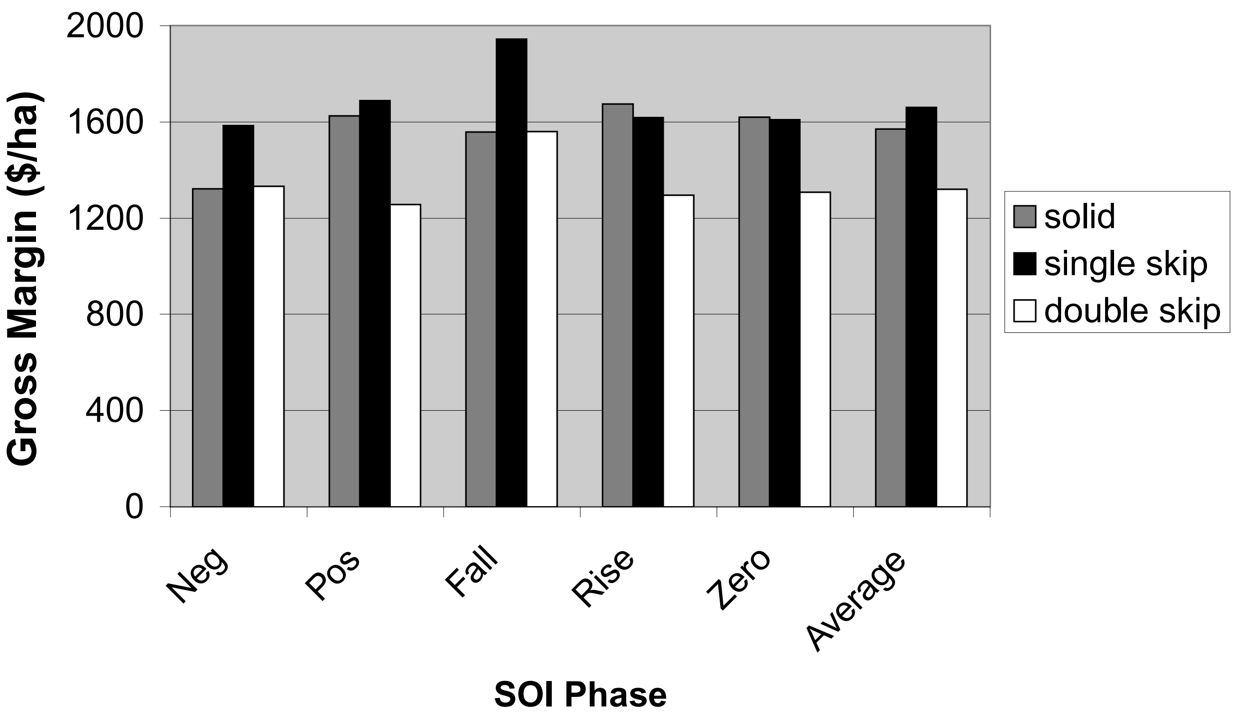

Figure 5: Predicted average gross margins for different row configurations with half a profile of soil moisture at sowing in Dalby for different phases of the SOI (Aug-Sep). (returns $450/bale, costs solid $1249, costs single skip $963, double skip $762).

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.