The influence of climate variability on cropping systems in Central Queensland

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Abstract

The current study evaluates and compares current cropping systems against the background of climatic variability at various time scales. The cropping systems model, APSIM, was used to simulate Central Queensland (CQ) cropping systems that are either summer or winter crop dominated. We used the Southern Oscillation Index (SOI) and a multi-Decadal Climate Variability (DCV) signal to investigate if knowledge of short and/or long-term climatic fluctuations could be used to reduce risks and increase profitability of cropping systems. The current trend of opportunity cropping winter as well as summer crops appears to be a well-adapted strategy based on the climatic patterns during the last two decades. Results further indicate that summer cropping might be less risky and more profitable than winter cropping during times when the DCV patterns are negative. However, results will be strongly affected by changes in cost/price ratios between the various crops considered.

Key Words

Cropping systems, systems management, decadal climate variability, SOI, APSIM, simulation model.

Introduction

Climate variability has considerable consequences for Australian crop production and its management. The use of seasonal climate forecasts based on El Ni?o/Southern Oscillation (ENSO) provides an opportunity to increase farm incomes and reduce environmental risks. Planting dates, sowing rates, crop choice and variety, fertiliser and other chemical inputs, fallow length and marketing strategies are all management options that can be adjusted by the grower, based on forecasts for the season ahead (1).

Farmers and those involved in the agricultural sector are well aware of the cyclical nature of rainfall variability. During the mid 1950s and 1970s, higher than average rainfall provided opportunities to reap higher yields and returns, whilst the early 1930s and 1990s brought drought and crop failure in many parts of Australia. The ability to understand, monitor and predict these climatic cycles may provide an opportunity to put historical experiences into perspective and to choose management strategies that are more appropriate for current climatic conditions.

Current research aims to incorporate climate forecasts with possibly higher skill and longer lead times into strategic decision making. Recent work on phenomena such as the IPO (Interdecadal Pacific Oscillation; 2) and related patterns (3, 4) indicates potential for tailoring long-term decisions, such as enterprise selection and rotation systems, to take advantage of the ‘good’ years, whilst minimising losses during the ‘poor’ years.

Central Queensland has a summer dominant rainfall pattern, with approximately 70% of the region’s annual rainfall falling between October and March. The annual median rainfall ranges from 601mm at Theodore to 690mm at Biloela. Most soils throughout the region are quite shallow (between 60-80cm) with low to medium nitrogen levels and a high water holding capacity per unit depth.

Originally, the primary crop grown throughout CQ was sorghum. However, the area sown to wheat has been steadily increasing and in the last 20 years (dependent on the season) has increased to an area similar to that sown to sorghum (5). Plantings of mungbeans and chickpeas are also increasing and provide the additional benefit of increasing soil nitrogen, without the risks associated with nitrogen fertiliser application.

Essentially, the cropping system that has developed in CQ is opportunistic. Fallowing the soil between crops to increase soil moisture is not a preferred option, due to the shallow nature of the soils and the high rates of evaporation. Consequently, fallowing only occurs when a planting opportunity does not arise or soils are sufficiently deep to allow significant carry-over of soil moisture into the next cropping season.

With the help of simulation analyses, this study investigates if the current cropping systems in CQ are well adapted to the region's climate variability. We also investigate likely performance of systems if climate patterns continue to change as they have in the past. By using today's costs and prices we compare a range of simulated cropping systems options against the background of climatic variability at various time scales. While producers only ever experience one particular outcome in any one season, such simulations allow us to quantify what the outcome of the same practice would have been under different climatic conditions.

Material and Methods

The case study centres on Emerald and uses four hypothetical, two-year crop rotations: a straight summer and a straight winter cropping system, as well as summer cropping with winter opportunity crops and winter cropping with summer opportunity crops (Table 1).

Table 1. Rotation sequence for the four cropping systems (crops in brackets indicate possible opportunity crops).

Rotations	*Year 1*		*Year 2*	
1) Summer Cropping	Sorghum	Winter Fallow	Mungbeans	Winter Fallow
2) Winter Cropping	Wheat	Summer Fallow	Chickpeas	Summer Fallow
3) Summer with Winter Opportunity Crop	Sorghum	(Wheat)	Mungbeans	(Chickpeas)
4) Winter with Summer Opportunity Crop	Wheat	(Sorghum)	Chickpeas	(Mungbeans)

For simulated plantings to occur, the model required set rainfall criteria and soil moisture conditions to be fulfilled. The systems performance was measured using October 2000 costs and prices to calculate financial year gross margins. This financial data was then analysed using either the SOI phase system (6) or an index of multi-decadal climate variability (3,4).

Results and discussion

Cropping in CQ is risky – winter rainfall in the region is low and erratic, and without high starting soil moisture levels, the risk of crop failure is high. However, as the 2000 winter seasons shows, results can occasionally be very rewarding. Summer cropping is less of a risk, particularly for crops planted in or after December, as the chance of follow up rain is high and the evaporation rate during the later parts of crop growth is falling.

Results show considerable temporal variability in the performance of the four cropping systems. Over the last 20 years, many growers in CQ have adopted a summer cropping system with winter opportunity cropping. When the last 20 years of simulated systems performance was examined (Fig. 1), winter cropping had the highest median gross margin, but the variability experienced was considerable. Examining the remaining three systems, it was summer cropping with winter opportunity cropping that performed the strongest, with a high median gross margin and less variability. Hence, the current trend of summer cropping with winter opportunity cropping crops appears to be a well-adapted strategy based on the climatic patterns during the last two decades.

A slightly different picture emerges when the last 99 years of simulated systems performance are considered. The ‘All Years’ median summer cropping gross margin is substantially higher than its value over the last 20 years, whilst the corresponding winter cropping value is much lower. The median gross margin for the opportunistic cropping systems showed little change, but variability for the summer cropping with winter opportunity crops is considerably higher.

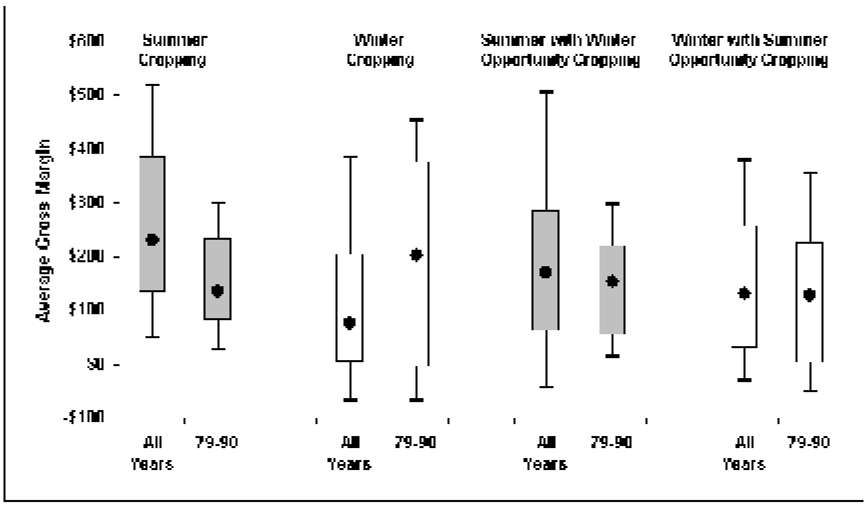

Figure 1. Box plots showing 10, 25, 50, 75 and 90th gross margin percentiles for each of the cropping systems for ‘All Years’ (1900-98) and the last 20 years (1979-98).

For most of the 1980s and 1990s we have been in a ‘positive’ DCV pattern. Using the DCV climate signal (4) showed that summer cropping was less profitable in positive DCV years than in negative years, with little impact on winter cropping. We found that in a negative DCV phase, summer crops with winter opportunity cropping performed better (Fig. 2). Similar results from the last 20 years (Fig. 1) and those from a positive DCV pattern (Fig. 2) seem to suggest that the climate variability associated with a positive DCV pattern is reflected in current systems management. However, results will be strongly affected by changes in cost/price ratios between the various crops considered.

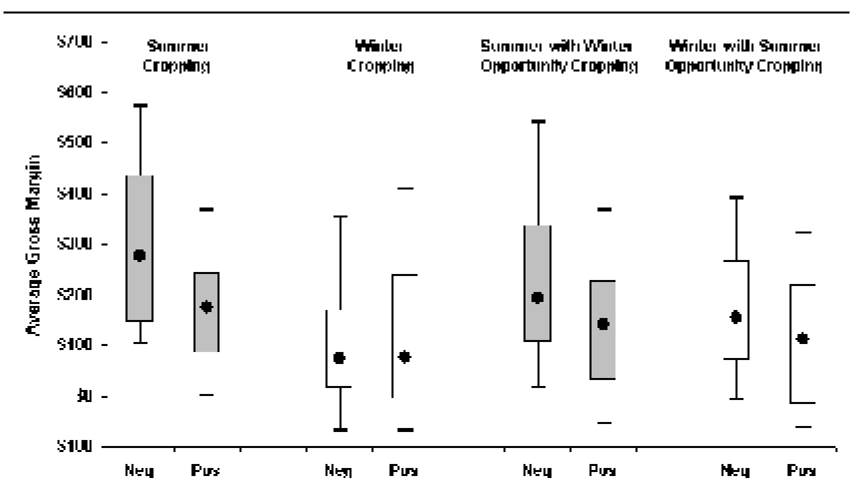

Figure 2. Box plots showing 10, 25, 50, 75 and 90th gross margin percentiles for each of the cropping systems in a negative and positive decadal climate pattern.

The May/June SOI had considerable impact on the median performance of the cropping systems. This relationship is strongest when the SOI is in a negative phase, during which the winter cropping based systems perform poorly. When the SOI was in a positive phase, the median gross margins increased for all but the summer cropping system. This confirms previous findings, indicating ENSO impacts mainly on winter and spring rainfall and subsequent crop performance in CQ (Table 2).

Table 2. Median gross margins ($/ha) for the cropping systems based on the May/June SOI phase.

SOI Phase	Summer Cropping	Winter Cropping	Summer with Winter Opportunity Crop	Winter with Summer Opportunity Crop
Negative	346.22	-27.17	136.21	113.94
Positive	225.81	131.19	220.18	144.06

Conclusions

The case study provides evidence of seasonal and multi-decadal impact on the economic performance of cropping systems in CQ. Results suggest that any multidecadal climate variability during the 1980s and 1990s might already be reflected in the current systems. This raises the question: when is the climate likely to shift again at these longer time scales and can climate science assist policy makers and producers to be better prepared for such changes in the future? These are the questions we attempt to answer in some of our current research activities.

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