Does ENSO influence the break of season in south-eastern Australia?

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Abstract

The variable time of the autumn break and the duration of sowing opportunities in the autumn period are important features of farming in south eastern Australian. A simple daily soil water balance model was developed to calculate plant available water during late summer and into the autumn sowing period. After testing the model with historical trial data we used the long term climate data to investigate the impact of El Ni?o, Southern Oscillation (ENSO) on 36 sites in south eastern Australia. Generally, the autumn break in El Ni?o years was delayed by 2 weeks, while seasonal breaks in La Ni?a years were 2 weeks earlier. The durations of sowing opportunities in April, May, June and July averaged, respectively to 4, 10, 18 and 22 days in El Ni?o years and 7, 16, 20 and 27 days in La Ni?a, while the changes in durations from all other years in the respective month were by -29%, -25%, -14%, and -15% in El Ni?o years and 48%, 33%, 10% and 10% in La Ni?a years.

Media summary

Farmers in south eastern Australia can expect to have their crops sown two weeks earlier than average in a La Ni?a year, or two weeks later than average in an El Ni?o year.

Key Words

Climatic variability, sowing dates, La Ni?a, El Ni?o

Introduction

Climate science has long been aware that El Ni?o Southern Oscillation (ENSO) has an impact on the amount and distribution of rainfall across eastern Australia (Nichols, 1998). However, much of the work applying ENSO to farming decisions has focussed in north eastern Australia. In the south east region winter crops are usually sown in May and June for optimal yields, but due to the variable rainfall, crops can be sown as early as April and as late as the end of July. An early break to the season is generally associated with higher yields from earlier sowing of winter crops and consequent increased biomass production (Kohn and Storrier, 1970; Shackley and Anderson, 1995; Hocking and Stapper 2001), and greater winter crop diversity (more canola and lupins in the rotation). A later break is associated with lower yields and a greater dependence on wheat and barley which has long term ramifications for the cereal root diseases in subsequent crops (Brennan and Murray, 1988).

The impact of ENSO on crop production through its influence on climatic variability is well-documented (Nichols 1985; Handler 1990; Hansen et al. 1999). Climatic variability associated with the impact of ENSO includes the amount of rainfall (Kane 1998; Nazemosadat and Cordery 2000), the distribution of rainfall (Rocha and Simmonds, 1997) and rainfall persistence (Simmonds and Hope, 1997). This paper examined the impact of ENSO on the amount, distribution and timing of rainfall on altering the onset of the sowing season and the duration of sowing opportunities in the south eastern Australian wheat areas.

Methods

The break of season can be defined as the time that the amount of rainfall exceeds the demand of evaporation so creating suitable crop sowing conditions within a sowing window. In central Queensland Hammer (1983) considered a rainfall of 20 mm in winter or 28 mm in summer over 1 or 2 days to be the criterion for planting on cracking clay soil. To test the impact of ENSO on break of the season in South Eastern Australia, we (i) developed a simple model to estimate the break of season, and (ii) studied the impact of ENSO on the break of season and the duration of sowing opportunity.

A simplified daily soil water balance model was developed to calculate plant available water during the late summer and into autumn. The break of season was then defined as the first time when sufficient rain had fallen within a “window" of opportunity for sowing; between 1-April until 31-July. The effective rainfall - the daily rainfall subtracting runoff and deep percolation (Obreza and Pitts, 2002), was calculated using an empirical equation and evaporation from the soil surface and was calculated using the CERES model’s two-stage evaporation approach. Because we are only modelling the surface soil, we are dealing with a system that has little ‘memory’ and is insensitive to rainfall and water stored in the soil over early summer. A sowing opportunity was defined as the time between when the moisture required for successful germination and emergence was met, the soil surface was not too wet (suitable for the passage of machinery).

The model was calibrated and validated against observed sowing dates in long term trials in Wagga Wagga from 1978 to 2002, and plant breeding trials. In the calibration, model estimation accounted for 79% of variation for the actual sowing dates from 1992 to 2002, while in the validation against the Wagga Wagga long term trails the predicted sowing data only accounted 49% of actual sowing dates. Nevertheless, in discussion with the researcher involved, the disagreed events were due to an artificial delayed or advanced sowing decision. The methodology was applied to calculate the break of the season for thirty-six sites across NSW and Victoria, ranging with 282 mm (Mildura) to 749 mm (Coonabarabran) of annual rainfall. The 36 sites were located in the latitudes from 30.98^{o}S (Coonamble) to 37.73^{o}S (Hamilton) and in the longitudes from 141.64^{o}E (Nhill) to 149.72^{o}E (Coolah). The seasonality of rainfall was expressed as the amount of rainfall falling in the winter growing season April to October (Sadras *et al.* 2003) ranged between 0.51 (Coonamble in central NSW) and 0.71 (Hamilton in Victoria).

According to the Bureau of Meteorology (Wright 2001) there were 21 La Ni?a events and 24 El Ni?o events between 1900 and 2002. The La Ni?a years are 1903, 06, 09, 10, 16 17, 24, 28, 38, 50, 55, 56, 64, 70, 71, 73, 74, 75, 88, 96, and 98, while the El Ni?o years are 1902, 05, 11, 13, 14, 19, 25, 40, 41, 46, 52, 53, 59, 65, 69, 72, 77, 82, 87, 91, 93, 94, 97, (and 2002). The remaining 58 years were neutral years. Although there are advances in the ability of climate science to predict El Ni?o and La Ni?a years, in this study we took a published list of ENSO events and examined the impacts of these events on the simulated break of season in SW Australia.

Results and discussion

There were 26 cases, out of 36, where the cumulative distributions of El Ni?o years or La Ni?a years were significantly different from all other years (5 sites P < 0.01, 11 sites P < 0.05, 10 sites P < 0.10), indicating ENSO has a considerable impact of on the seasonal break in south eastern Australia.

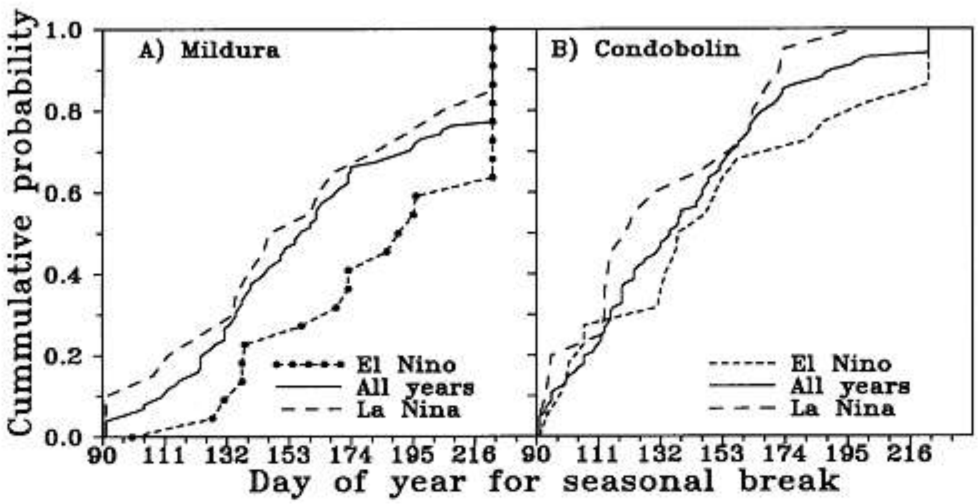

Figure 1. Break of season in La Ni?a, El Ni?o and All years. The broken line with dots indicates that the cumulative distribution is significantly different from the all other years (solid line).

The difference in the days of year for the seasonal break between ENSO and all other years at Hillston and Mildura was the largest for La Ni?a and El Ni?o years, while Hay and Swan Hill were the smallest for La Ni?a and El Ni?o years, respectively. The 50th percentile of cumulative distributions for seasonal breaks in La Ni?a years across all sites ranged from 12 days later to 28 days earlier than all other years, while that in El Ni?o years ranged from one day later to 40 days later than all other years (data not shown). Figure 1 showed the shift of cumulative probability of seasonal break in El Ni?o and La Ni?a years in Mildura (Figure 1A) and Condobolin (Figure 1B) from all other years. At the 36 sites, there was no significant differences ($P > 0.1$) in the cumulative distributions between neutral years and all other years (which included all years of La Ni?a and El Ni?o).

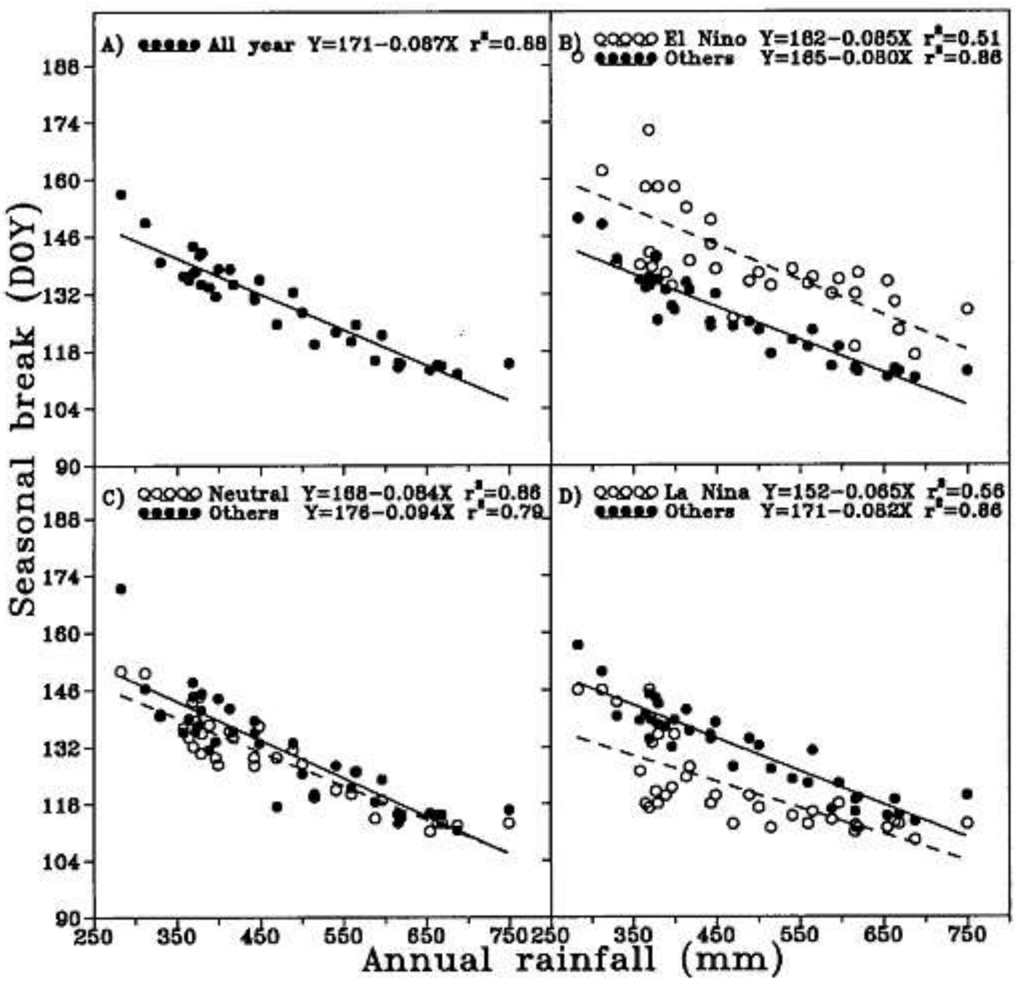

Figure 2. Relationships between annual rainfall and seasonal break at all years (A), El Ni?o years (B), neutral years (C) and La Ni?a years (D) at 50th percentile of the cumulative probability distributions across 36 sites in South Eastern Australia.

There were linear relationships between the occurrence of seasonal breaks and the long-term annual mean rainfall within the 36 sites. The linear relationship accounted for 88% of the variation for the 50th percentile of the cumulative probability distributions (Figure 2A). The slope of -0.087 indicated that for each 100 mm change in annual rainfall, the seasonal break will be about 9 days earlier. Within El Ni?o years, the two intercepts (day of years for seasonal break at nil rainfall is 182 and 162 for El Ni?o and all other years, respectively) were significantly different ($P < 0.01$), while the two slopes of the linear relationships were not significantly different ($P > 0.1$). This predicted that the seasonal break in an El Ni?o year was, on average, 15 days later than all other years. In the La Ni?a years, both intercept and slope were significantly different from all other years ($P < 0.01$). In low rainfall sites (i.e. 250 mm), a La Ni?a year had a seasonal break 15 days earlier than all other years, while in high rainfall (i.e. 750 mm) the seasonal break was 6 days earlier than all other years (Figure 2 D). The shift in the timing of the break was in the order of two weeks earlier or later than normal. In the neutral years, the seasonal breaks were not significantly different from all years (Figure 2C).

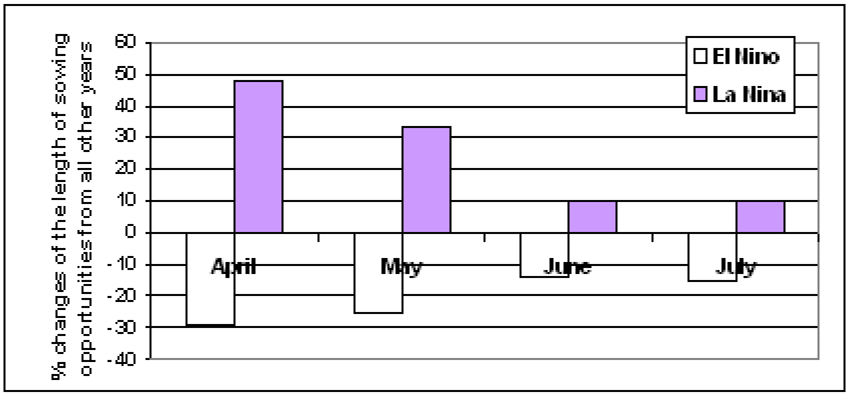

Figure 3. The averaged percentage of changes over 36 sites in the length of sowing opportunities from all other years during sowing season.

The duration of sowing opportunities was also linearly related to annual rainfall. The correlation coefficients between the duration of sowing opportunities and annual rainfall were ranged from 0.72 to 0.92 in April, 0.63 to 0.72 in May and 0.36 to 0.53 in June, indicating the relationship became weaker as the sowing season progressed (data not shown).

On the other hand, over the 36 sites the average duration of April sowing opportunities in El Ni?o years was 30% shorter than all other years, while the average duration of April sowing opportunities in La Ni?a years was 48% longer than all other years (Figure 3). As the sowing season advanced, the differences in the duration of sowing opportunities in La Ni?a years and El Ni?o years were smaller (respectively 10% longer and 15% shorter than all other years). However, the actual days duration of sowing opportunities in April, May, June and July averaged respectively 4, 10, 18 and 22 days in El Ni?o years and 7, 16, 20 and 27 days in La Ni?a years. The changes in days duration of sowing opportunities in ENSO years from all other years ranged 2 to 4 days in a month were less significant to farmers.

This study showed that the seasonal break can be adjusted (implying no yield penalty), by using a simple soil water balance model for calculating plant available water for plant germination and emergence and integrating seasonal climate forecasts. Seasonal break varied depending on locations, and El Ni?o and La Ni?a years. Not surprisingly, there were highly significant correlations between seasonal breaks and annual rainfall. The earlier seasonal break associated with the La Ni?a years should be exploited by farmers with an early sowing as La Ni?a years are also associated with higher spring rainfall and cooler daytime temperatures in the region (Jones and Trewin 2000), combined with reduced frost risk (Willcocks and Stone 2000).

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