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Tropical pasture establishment. 17. Prospects for using weather prediction to reduce pasture establishment risk

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Abstract

Relationships between Southern Oscillation Index (SOI) phases, that include a change of SOI value from month to month, and summer pasture sowing opportunities at a number of locations in northern Australia have been investigated. The number of planting opportunities, date of first planting opportunity, number of days to second opportunity and the probability of obtaining a planting opportunity were all significantly related to the SOI phase for the previous December. The degree of relationship varied with the location being analysed.

Planting opportunities at locations in the more northern and western areas were affected to a greater degree by the El Niño/Southern Oscillation than those at other locations. Low SOI values during December appeared to be related to fewer planting opportunities, higher probability of not receiving a planting opportunity at all, higher probability of not receiving a second planting opportunity, and a longer interval between planting opportunities.

The relationship between the 30–50 Day Oscillation and planting opportunity was investigated. On 50–60% of occasions, passage of the 30–50 Day Oscillation was associated with a planting opportunity within the following 10 days and 30–50 days later.

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Introduction

The main land use in northern Australia is pastoralism based on beef cattle. Pasture growth determines safe stocking rates but is highly dependent on summer rainfall (Hammer *et al.* 1991). Rainfall in northern and eastern Australia is highly variable and is strongly related to El Niño/Southern Oscillation activity (Nicholls 1987;1991). Although predictions of crop yield incorporating an index of the Southern Oscillation (SOI) (Nicholls 1986; Hammer *et al.* 1991) have been made, relationships between the SOI and pasture establishment have yet to be determined. Recent developments in climate research have also focussed on the effects of the 30–50 Day Oscillation on the timing of rainfall events in Australia (Suppiah 1991). The 30–50 Day Oscillation is a periodic wave disturbance that originates in eastern African regions and progresses eastwards with a mean periodicity of 40 days across northern Australia (Madden and Julian 1972). Higher rainfall may occur during the passage of the 30–50 Day Oscillation during periods of opposite extreme to El Niño (La Niña). It has yet to be determined whether the 30–50 Day Oscillation might be beneficial in planning crop or pasture sowing events.

Our objective in this study was to evaluate the usefulness of existing skills in seasonal forecasting using SOI-based methods in pasture establishment for northern and eastern Australia. Usefulness of knowledge of the timing of the 30–50 wave would also be evaluated.

Methods

Criteria for defining planting opportunities generally include a minimum amount of rainfall within a specified time. Hammer *et al.* (1987) used a combination of rainfall amount, time of year and a drying requirement to predict when a farmer should plant a crop on vertisols. Peacock and Sivakumar (1987) used 20 mm of rainfall accumulated over 3 consecutive days with no period of rain longer than 7 days within the next 30 days to define planting events in east Africa. Vanderlip *et al.* (1993) used the following criteria: (i) rainfall in excess of 30 mm accumulated over 2 consecutive days; (ii) rainfall exceeding evaporation until it exceeded 20 mm; and (iii) as in (ii) rainfall exceeding evaporation by 20 mm followed by a soil drying requirement of evaporation exceeding rainfall by at least 15 mm. Criterion (iii) was considered a suitable base on which to conduct this study as sowing opportunities depend mainly on sufficient stored soil moisture providing follow-up rain eventuates (D. Lloyd, personal communication). The above criteria were based on planting on vertisols. The criteria above may need to be varied based on local experience for different soil types and surface management (Vanderlip *et al.* 1993). The planting window was assessed as occurring between January 1 and March 1.

SOI categories have been used effectively to assess the probability of occurrence of future rainfall (Clewett *et al.* 1991). SOI 'phases' which incorporate both change in SOI and absolute SOI value have been used effectively in partitioning both simultaneous rainfall (Stone and Auliciems 1992) and future rainfall (Stone and Hammer 1992). Consistently positive or rapidly rising SOI over a 2-month period is generally associated with above-average rainfall while consistently negative or rapidly falling SOI is generally related to below-average rainfall. Five SOI phases have been identified objectively using principal components/cluster analysis techniques. These were:

(i) consistently negative SOI, mean SOI −12.1;
(ii) consistently positive SOI, mean SOI +9.5;
(iii) rapidly falling SOI, current month SOI −10.0, previous month +2.7;
(iv) rapidly rising SOI, current month SOI +6.6, previous month −4.4; and
(v) SOI near zero with little change over time, mean SOI −1.7.

Relationships of SOI phase with future crop yield have also been demonstrated (Hammer *et al.* 1991; Stone and Hammer 1992). Thus, for the present exercise, it was decided to examine relationships between SOI phase and the number of first planting opportunities and days to any second planting opportunity.

Timing of rainfall events in northern Australia may be associated with the 30–50 Day Oscillation (Suppiah 1991). Rainfall occurring during the 2-week interval centred on the passage of the 30–50 Day Oscillation is generally higher than at other periods (J. Carter, personal communication). Therefore, dates of known passage of this disturbance were identified to examine its value in predicting optimum sowing dates. These are calculated from Darwin pressure series and changes in upper wind patterns, based on data supplied by R. Stringer, Bureau of Meteorology, Darwin.

To quantify the occurrence of planting opportunities, cumulative probability distributions based on the previously defined criteria of Vanderlip *et al.* (1993) were calculated and partitioned according to the SOI phase determined for December. Calculations were made of the date of first planting opportunity, number of days to possible second opportunity, percentage of years when no planting opportunity occurred, and mean number of planting opportunities. Locations analysed were Tamworth (31.1 °S, 150.5 °E), Goondiwindi (28.4 °S, 150.3 °E), Dalby (27.2 °S, 151.2 °E), Roma (26.5 °S, 148.7 °E), Banana (24.1 °S, 150.1 °E), Emerald (23.5 °S, 148.1 °E) and Charters Towers (20.0 °S, 146.1 °E). The locations form a general north-south transect of stations through eastern inland Australia.

An accurate record of the passage of the 30–50 Day Oscillation during the January–February planting window was obtained for 46 occasions since 1961. Relationships of the 30–50 Day Oscillation to sowing/planting events at Charters Towers, Roma, and Goondiwindi were investigated.

Results

Date of first planting opportunity

Except for locations at the southern extremity of the transect, the median date of first planting opportunity tended to be later when a consistently negative SOI existed before the planting window compared with a consistently positive SOI. At Emerald for example, the all-years median date of first planting opportunity occurs on January 23 (23rd day of the year). However, following a consistently negative SOI phase, the median date is extended to February 1 (32nd day of the year), while following a consistently positive SOI, the median date of first planting opportunity occurs on January 15 (15th day of the year) (Figure 1). This result is generally true for more-northern locations, but the trend reverses further south. At Dalby the median date of first planting opportunity is similar after positive and negative SOI phases and at Tamworth, the median date of first planting opportunity occurs earlier when negative SOI phases exist before the sowing window. Interestingly, at Goondiwindi and Tamworth, the latest median date of first planting opportunity occurs when SOI values near zero exist before the sowing window.

Mean number of planting opportunities

Number of planting opportunities in January–February exhibits the following pattern:

1. The lowest numbers of planting opportunities occur at Charters Towers, Emerald, Roma, and Dalby when consistently negative SOI phases exist prior to January 1. At Goondiwindi and Tamworth, the lowest number of opportunities exists when SOI values are about zero. As an example, mean number of planting opportunities for Roma appear in Figure 2.
2. The highest number of planting opportunities occurs when a consistently positive SOI exists before January 1 at all locations except Tamworth. Overall about 3 times as many planting opportunities follow consistently positive SOI occurrences as follow consistently negative SOI occurrences.
3. The reason for the relatively high number of planting opportunities following a fall in SOI is unclear. However, from initial inspection of SOI phase transition from month to month, it appears common for a fall in SOI during November–December to be followed by a rapid rise in SOI during January–February, presumably associated with increased rainfall.

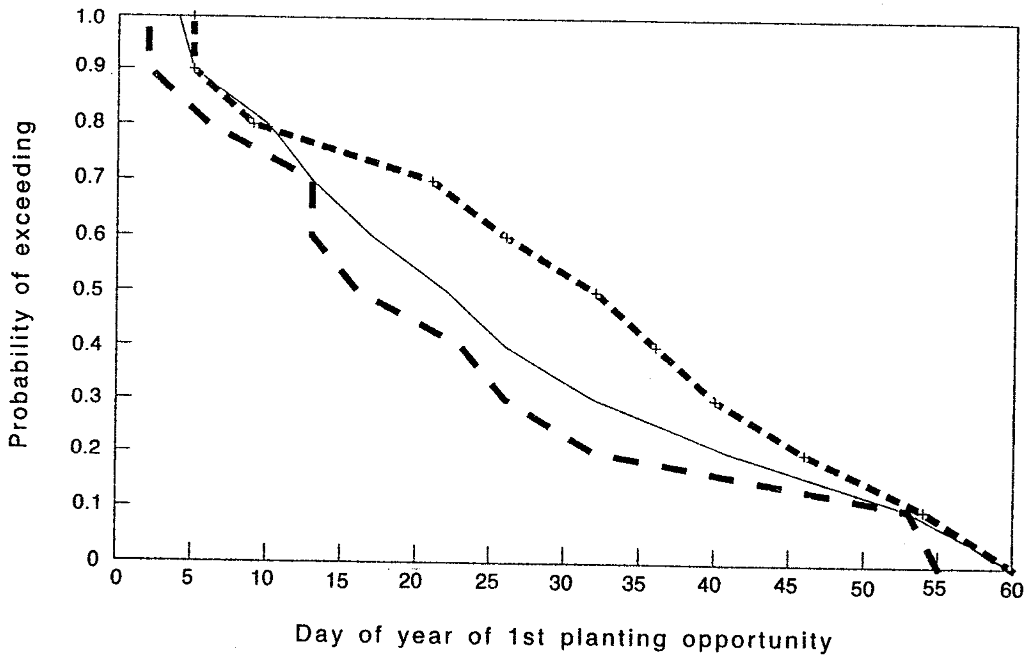

Figure 1. First planting opportunity at Emerald, January–February in all years (—), years with positive (——), and years with negative (---) SOI phase in December.

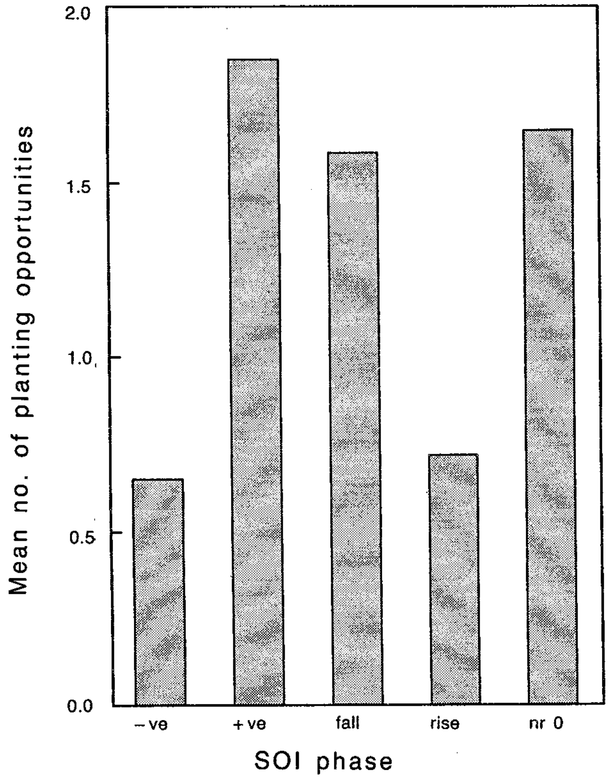

Figure 2. Mean number of planting opportunities at Roma in January–February according to SOI phase in December.

Number of days to second planting opportunity

An examination of the number of days to a second planting opportunity reveals a median period of approximately 12 days when a positive SOI phase exists before January 1, and about 18 days when a negative SOI phase exists. For example, at Emerald (Figure 3a), the mean number of days to a second planting opportunity is approximately 12 days following a positive SOI phase in December, compared with approximately 20 days following a negative SOI phase. However, at Roma (Figure 3b) there have been no cases of a second planting opportunity following a consistently negative SOI phase in December. Conversely, at Dalby, SOI phase in December had little effect on time to second planting opportunity. The relationships between SOI phase and planting opportunities may be reflecting an increasing correlation between SOI phase and total rainfall with increasing distance from the coast in northern NSW and Queensland (McBride and Nicholls 1983).

Probability of no planting opportunity

At all locations, the probability of no planting opportunity is lowest following a consistently positive SOI phase in December. For example, risk values as low as 5% occur at Emerald and 10% at Roma (Figure 4). This contrasts with a risk of not achieving a first planting opportunity of 68 and 38%, respectively, following a consistently negative SOI phase.

Probability of no second planting opportunity

The probability of not receiving a second planting opportunity is generally lowest following a positive SOI phase in December. At Emerald, the probability of not receiving a second planting opportunity following a consistently positive SOI phase is 26%. Conversely, the probability following a consistently negative SOI phase is 58%. However, at Dalby, the probability increases from 50% following a negative December SOI phase to 71% following a consistently positive

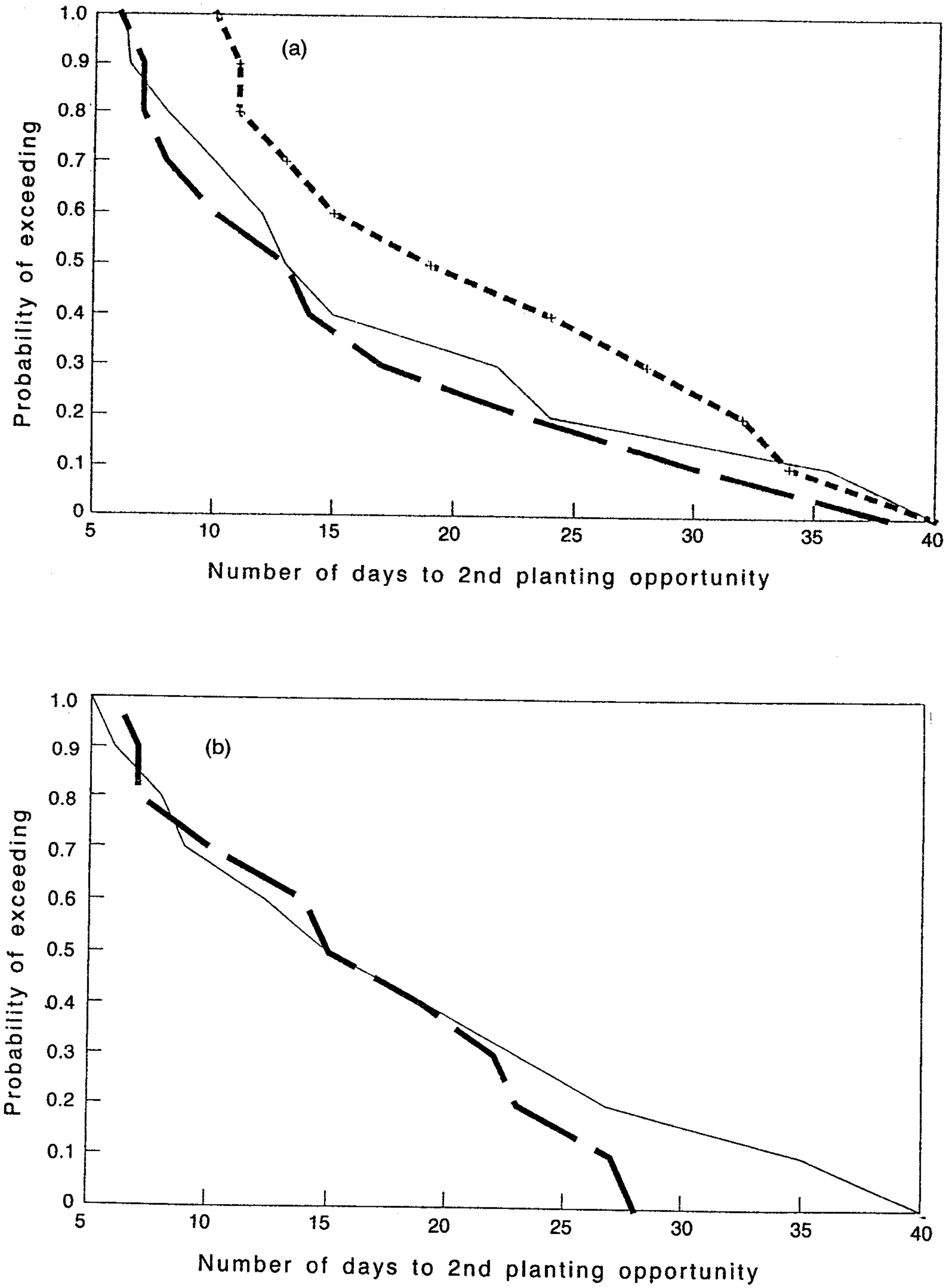

Figure 3. Probability of exceeding certain number of days to second planting opportunity at (a) Emerald and (b) Roma in January-February, in all years (—), and years with positive (——), or negative (---) SOI phase in December. No 2nd planting opportunities following −ve SOI in December at Roma.

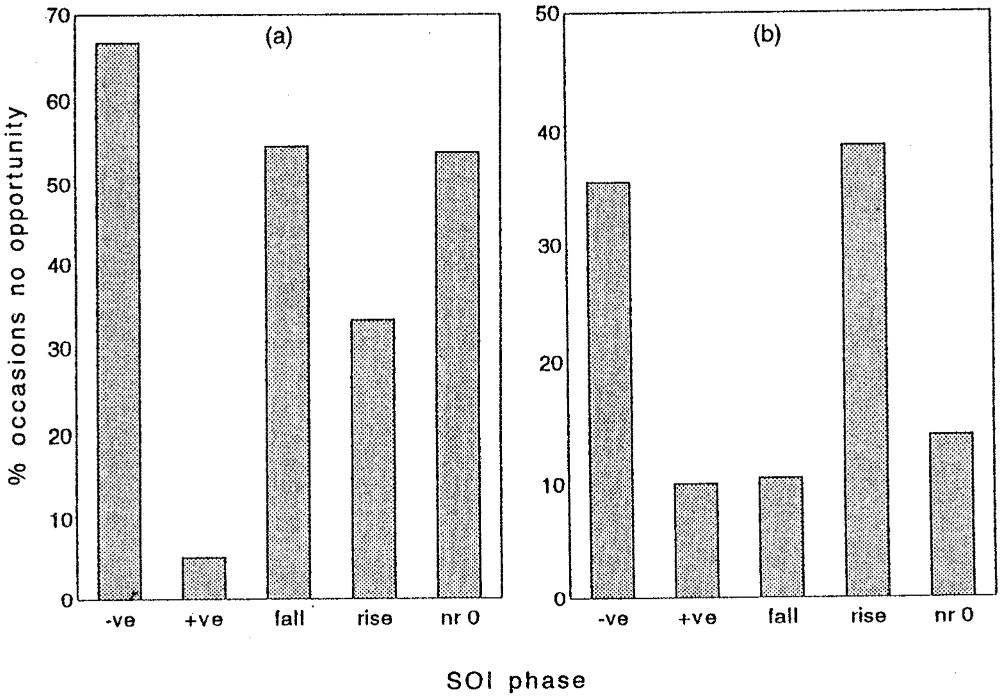

Figure 4. Probability of not obtaining a planting opportunity at (a) Emerald and (b) Roma during January–February, according to SOI phase in December.

SOI phase (Figure 5). Thus, although it was noted earlier that little difference occurs in days to second planting opportunity at Dalby, the probability of not obtaining that second opportunity is reduced following a consistently negative SOI phase. An interesting feature of the data for Dalby and Banana is that the probability of not obtaining a second planting opportunity is lowest following a rapid rise in SOI during December.

Use of the 30–50 Day Oscillation

The percentage of occasions for which passage of the 30–50 Day Oscillation was followed by a sowing event in another 30–50 days (i.e. during the next passage of the oscillation) was 59% at Charters Towers, 62% at Emerald, and 53% at Roma. Occasions when the 30–50 Day Oscillation were recorded passing across Darwin, when a planting opportunity was obtained within 10 days of this passage at Emerald, and when another opportunity was obtained 30–50 days later at Emerald since 1979 are given in Table 1.

Table 1. Date of passage of 30–50 Day Oscillation near Darwin and occurrence of planting opportunity within 10 days and further 30–50 days at Emerald, Queensland between 1979–1988.

30–50 day oscillation date	Planting rain within 10 days of oscillation date	Planting rain in 30–50 days
24.12.88	no	yes
23.12.87	no	no
24.1.87	yes	no
26.2.86	yes	no
21.1.86	no	yes
14.2.85	no	no
14.12.84	yes	no
7.1.83	yes	no
17.1.82	yes	yes
4.12.81	yes	yes
14.2.81	no	yes
14.1.81	no	no
13.2.80	no	no
5.1.80	yes	yes
1.2.79	yes	no

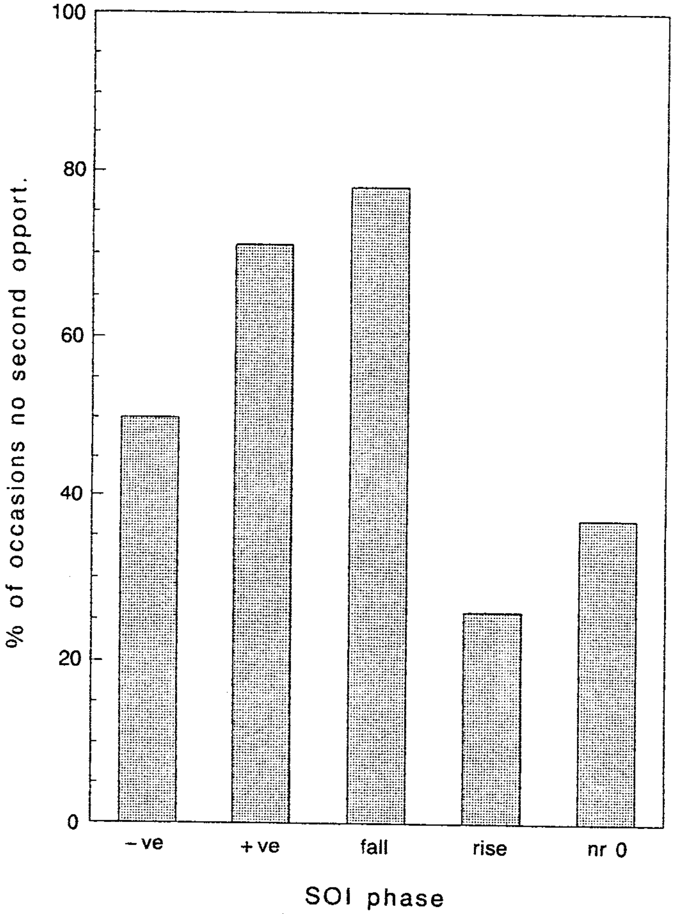

Figure 5. Per cent of occasions when no second planting opportunity occurred at Dalby during January-February, according to SOI phase in December.

When years were partitioned into El Niño or La Niña years (as defined by Suppiah, personal communication), type of year had no effect on probability of a planting opportunity following passage of the 30-50 Day Oscillation. However, the sample used may have been too small for accurate comparisons to be made. Further comparisons revealed that, after a consistently positive SOI phase in December, the probability of receiving a planting opportunity during the 30-50 day period following the known passage of the 30-50 Day Oscillation was 73%. Conversely, a planting opportunity was recorded within this period on only 25% of occasions when the preceding December SOI phase was consistently negative. Once more, the sample size was insufficient to derive results that were statistically significant.

Non-parametric statistical tests have been applied to the preceding probability distributions. In most cases, the distributions were significant at ($P < 0.01$) and ($P < 0.05$), depending on the particular differences being analysed. Thus, the changes in distributions of planting opportunity according to the SOI phases are a significant indicator of the risk associated with pasture establishment.

Discussion

The main finding from our study is that planting opportunity during January–February at the locations analysed is closely related to the SOI phase in the previous December. Based on the criteria for a planting opportunity used in this initial analysis it appears that few planting opportunities occur in northern Australia during January–February but that the probability is greater following a positive SOI phase in December. Conversely, the probability of obtaining a planting opportunity following a negative SOI phase in December is generally low, especially at locations such as Roma. Indeed, at Roma, if a planting opportunity is missed there is little likelihood of a second opportunity (or follow-up rain) following a negative SOI phase in December. At all locations there is much less risk of waiting for a second planting opportunity if the SOI phase in December was consistently positive.

Usefulness of the 30–50 Day Oscillation in pasture establishment requires further investigation. It is emphasised that the results obtained were dependent on the rainfall criteria established by Vanderlip *et al.* (1993). However, it would appear that a more comprehensive data base containing 30–50 Day Oscillation dates of passage would benefit further research. The lack of suitable upper-air analyses prior to about 1950 means that accurate pinpointing of the date of passage of the 30–50 Day Oscillation may remain a problem for some time.

We stress that this study represents an exploratory research attempt using present seasonal forecasting methods. Improvements to forecasting techniques involving factors beyond El Niño/SOI such as global sea-surface temperature anomalies are needed to allow greater accuracy in predicting whether future weather conditions will be conducive to successful pasture establishment. Although this study concentrated on eastern and northern Australian regions, we believe the approach developed may be applicable generally.

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