A simple, self adjusting rule for identifying seasonal breaks for crop models

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Abstract

A variety of ad hoc rules have been used to determine crop sowing dates for modelling purposes. Many of these have no mechanistic base providing little basis on which to choose between them for a given application. We present here a simple, effective rationale for determining crop sowing dates which appears to be robust across the years and locations in Australia where we have been able to obtain sowing date information. This is based on the weekly ratio of rainfall to pan evaporation, and when rainfall exceeds pan evaporation, a sowing opportunity is deemed to have occurred. Considering the simplicity of the approach it appears to work quite well across the breadth of the Australian cereal cropping zone. It could possibly be employed for annual pasture germination as well as crops.

Key Words

sowing rules, climate, delayed sowing, modelling

Introduction

In rainfed agriculture the sowing time of annual crops is determined by seasonal conditions, particularly the availability of surface soil moisture for seed germination. The growing season for the primary annual crops in Australia is from autumn (April-May) to late spring (October-November), or until early to mid summer (December-January) in the wetter cropping areas. While early sowing is recognised as paramount for attaining maximum yields for all crops in these environments, germination and growth can only commence after sowing once sufficient rains have fallen and the topsoil is moist. In Table 1, we summarise sowing rules used in some Australian studies where rainfall has been the primary determinant used to identify the break of the season. Most of the studies used the Agricultural Production Systems Simulator (APSIM) and these employed a range of ad hoc rules, or alternatively sowing was set to specific dates (e.g. Farre *et al.* 2001a; Robertson and Kirkegaard 2005). What constitutes "significant opening rains" for a given crop will vary depending on soil type, stored soil water and the week of the year and there appears to be no particular system for determining when a seasonal break occurs for modelling purposes. The present paper investigates the use of a simple universal rule for predicting sowing/germination dates for modelling purposes.

Table 1. Sowing rules used in some Australian modelling studies.

Crop and environment	Sowing rule
Canola (WA)	April 15 and June 1 if >25mm rain fell over 5 days, or the soil had >50% of plant available water capacity, after June 1 >10mm rain/5 days (Farre *et al.* 2001b)
Wheat (NSW)	20mm/10 days until 15 June, 15mm/10 days thereafter (Asseng *et al.* 2003)
Wheat (WA)	step function, 25mm/10 days before 5 June or 10mm/10 days thereafter (Asseng *et al.* 2001)

Wheat (Warra, Qld)	50% of field capacity in 20-40cm soil and ≥60mm PAW in top 150cm and 25mm/10days from 1 May to 25 August (Asseng *et al.* 2002)
Lupin (WA)	15 mm/5 days (Farre *et al.* 2003)
Canola (nth NSW)	20mm/10 days between May 1 and 31 July (Robertson and Holland 2004)
Wheat (Eyre Pen., SA)	10mm/2 days (Huda *et al.* 1993)
Wheat (SA)	10mm/day between 20 April–10 July (Reyenga *et al.* 2001)

Methods

Crop sowing dates were obtained for locations across Australia, selected on the basis of distribution across the major cropping environments. Some data were for individual long-term trials, specific sites with a single sowing date each year (Warra, Harden, Tarlee), while the remainder of the sites were 'nominal' with a range of different research trials at different specific sites for a nominal location. For these the sowing dates were averaged for each nominal location across trials. Sowing date trials were excluded, or only the first sowing date included. One dataset was obtained from a farmer at Brinkworth (SA). For each of the locations, daily rainfall and pan evaporation data were obtained from the SILO database (Jeffrey et al. 2001).

A simple sowing rule was devised using the ratio of rainfall to pan evaporation, if the sum of rainfall over any seven-day period exceeded pan evaporation over the same period, then a sowing opportunity was deemed to have arisen. The basis for this was that it should generally indicate that the soil was wetter at the end of the week than the beginning. Pan evaporation was chosen because it reflects the net effect of a number of climate parameters on evaporative demand and because it naturally scales with the growing season. This apparently simple concept does not appear to have been considered previously, although average values have been used to define growing season lengths (e.g. Marshall 1973; Prescott 1938). The model was initially run with the sowing window opening on day 110 (April 20) but as sowing rarely if ever occurred before the first week of May in the dataset, the sowing window was not opened until May 1, this gave closer correlations with actual sowing dates. For Warra in Qld, the simple fallow water balance model of Fitzpatrick and Nix (1969) was used to accumulate water over the fallow period, infiltration was restricted to 50mm/ 3 days (see Freebairn and Boughton 1981), and sowing was not permitted unless at least 50mm of stored soil water was indicated. For all other sites no soil water storage condition was imposed as it did not improve correlations between modelled and actual sowing dates.

Results

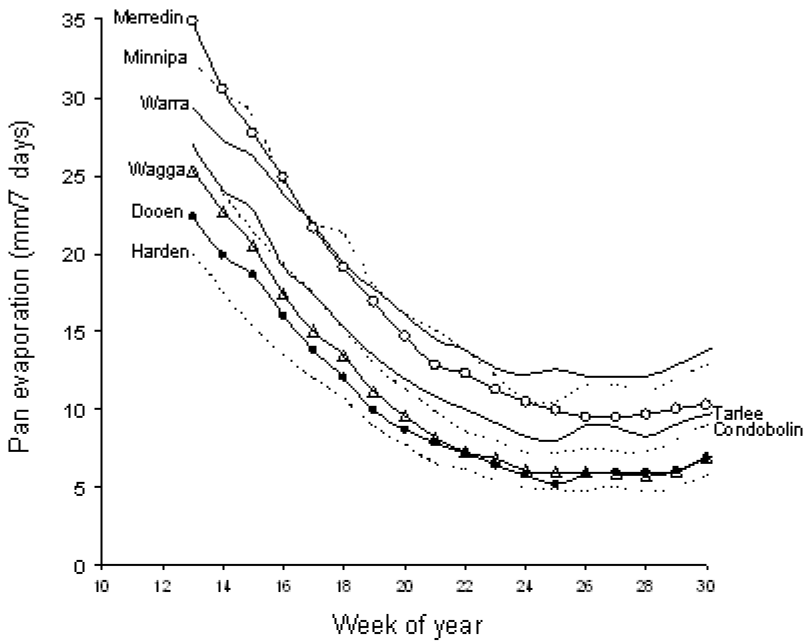

Figure 1. Average weekly pan evaporation for eight sites across the Australian cropping zone.

Merredin in Western Australia (WA), Minnipa (SA) and Warra (Qld) have the highest evaporation rates, although Merredin is a little more benign in June. By the beginning of May about 10mm of rain might be required to sow in Harden and only 5mm by the second week of June, whereas in Minnipa for example, >10mm would be required at this time. Figure 1 highlights how the simple sowing rule will adjust for the progression of changing evaporative demand across different weeks and regions. It also highlights how much more rain (>20mm) is required for the establishment of an early (April) seasonal break at all sites, except perhaps for Harden in NSW.

Actual sowing dates for a given nominal location *x* year varied by up to 30 days (data not shown).The apparent success of the sowing model varied between sites datasets (Figure 2) but tended to be closer to actual sowing dates in more recent years, perhaps a consequence of the adoption of reduced tillage and better weed control facilitating earlier sowing in more recent years. Closest agreement was found with the single set of commercial farm data (Brinkworth, SA) (Table 2), perhaps indicating that it takes more time to sow research trials in disparate locations than a farmer may take to sow their crop. On average, research trials appear to be sown about ten days after the identified seasonal break.

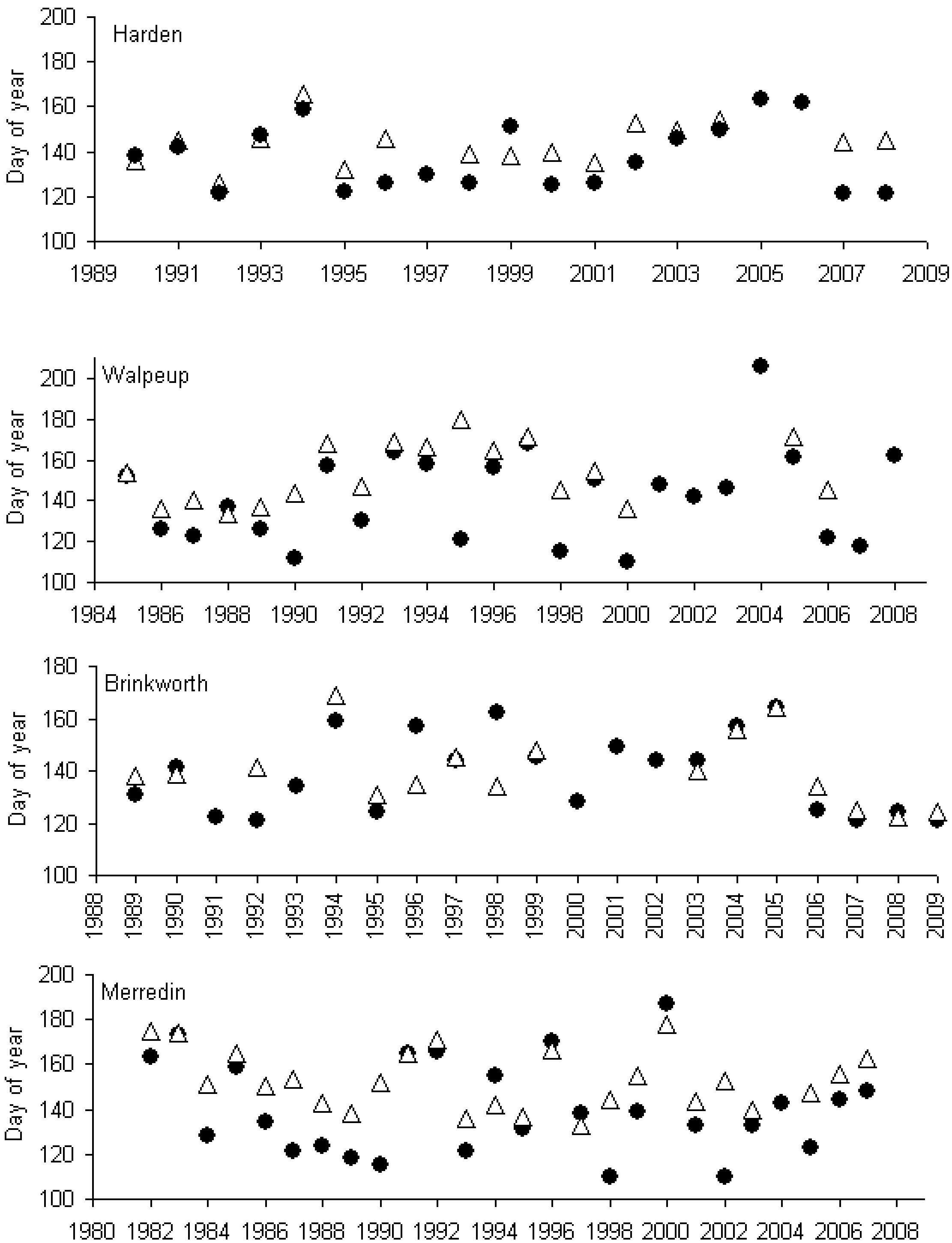

Figure 2. Comparison of actual (∆) and modelled (●) sowing dates for four locations.

Discussion

Although we have not done a comparison with the myriad of rules used previously, the approach used here may work better than others as it takes local conditions into account in both time and space, without a need for ad hoc adjustment. As evaporation probably changes little from year to year for a given week and location, average weekly evaporation might work as well as the actual pan evaporation rates used here. We opened our sowing window on 1 May rather than 1 April as this achieved a closer fit to the actual data, and certainly growers in WA seem reluctant to sow before the last week of April (Armstrong 1998). Different amounts of rain are likely to be required to establish suitable conditions for sowing in different environments and indeed on finer textured soils, too much rain will delay sowing. In eastern Australia where rainfall is more equiseasonal in distribution and stored soil water is important, the amount of rain needed to 'sow' may be less than that required to signify the 'seasonal break' if there is a reasonable store of soil water (Stephens and Lyons 1998). Nevertheless the apparent simplicity and self adjusting nature of the present model may provide a valuable tool for those needing to identify the start of sowing for modelling purposes

Table 2. Difference between modelled break and actual sowing date for different locations.

Location	Days	Comments
Warra	-26	years 1987-1998 and is from a single trial, precedes adoption of reduced tillage, herbicides and earlier sowing, fine textured soils
Condobolin	-5	
Harden	-9	
Wagga	-7	
Dooen	-21	years 1981-1991, precedes adoption of reduced tillage, herbicides and earlier sowing.
Birchip	-13	
Walpeup	-10	
Brinkworth	0	dataset of actual farm sowing dates
Tarlee	-34	years1978-1993, precedes the widespread adoption of reduced tillage, herbicides and earlier sowing.
Minnipa	-8	
Merredin	-8	
Wongan	-12	

Hills

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