Differences among wheat cultivars in their optimum sowing times in Western Australian environments

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Abstract

Cultivar performance in wheat varies with time of sowing, which is contingent on the time of seasonal break in rainfed agriculture. We conducted more than 25 field experiments with 2-3 times of sowing after the break of the season over three years at sites spread throughout the agricultural belt of Western Australia. An analysis of variance model with a Genotype x Environment x Management (time of sowing) structure and a sowing 'window' (using smoothing splines) approach was used to analyse the grain yield data.

Cultivars differed for optimum sowing windows and penalties for early sowing (ESP) or late sowing (LSP). In 2005, the LSP was generally greater than ESP and that the decline spectrum for cultivars was wider with late sowings. We conclude that (i) sowing wheat at the first available opportunity may not always be the best economically; rather cultivars need to be matched to sowing time according to their time of flowering and maturity; (ii) cultivars in the low ESP group are either long season cultivars or have sufficient plasticity in their yield components, in contrast to high ESP cultivars which have a medium to short life cycle coupled with low plasticity for yield components; (iii) most common cultivars in WA have a relatively wide sowing window; (iv) cultivar options available to growers outside the most common time of break of season in WA, especially early sowing, are limited; and (v) growers should keep sufficient quantity of seed of a range of cultivars to cover all likely sowing times.

Key Words

Wheat, time of sowing, sowing window, optimum sowing time, rainfed

Introduction

Cereal growers are faced with a greater choice of new cultivars both from the public and private sectors, often with little relevant information available on their performance in the local environment. Climate and weather conditions greatly influence the performance of new wheat cultivars both for yield and quality. One of the key management factors used to manage this variation is time of sowing (TOS).

Over the last two decades, early sowing has been seen as an opportunity to achieve higher yields in WA (Anderson et al 2005), in contrast to late sowing which results in late-season stresses that reduce yields and quality characteristics such as small grain screenings (Sharma and Anderson 2003, 2004). The advantages of early sowing for maximising water use and allowing a longer and milder grain filling period have been explored in WA in previous studies (Delane and Hamblin, 1989; Anderson and Smith, 1990; Anderson et al. 1996). While Kerr et al. (1992) found mid-May to early-June to be the best TOS in the north-eastern wheat belt of WA (actual seasonal rainfall 198-324 mm; average seasonal rainfall 200-260 mm), Anderson et al. (1996) showed the potential to extend the sowing season by planting in late April rather than early May in the central wheat belt (actual seasonal rainfall 176-330 mm; average seasonal rainfall 200-350 mm) without downgrading grain quality, through adoption of appropriate cultivars. These studies suggested that targeting a flowering window, estimated on the basis of rainfall, frost risk and season length, was preferrable. These flowering windows have been found to be fairly stable at sites over years (Anderson et al. 1996). However, most studies involved a limited number of cultivars, many of which are now obsolete. In fact, the choice of cultivars available now is much greater than ever before and having been selected in more diverse environments and emerging from diverse parentage, they are likely to be genetically more diverse in their adaptation. This study was planned with a view to understanding the cultivar by TOS interactions in a range of wheat growing environments in WA using a wide range of cultivars and seasons to develop strategies for maximising benefits to farmers.

Methods

Twenty five cultivar by TOS experiments were conducted over three crop seasons (2003-2005) in different Agzones of WA. The sites were located at: Mullewa (115.45?E, 28.58?S) and Eradu (114.94?E, 26.68?S) in the north, Quairading (117.52?E, 32.02?S) and Mukinbudin (118.17?E, 31.03^{0}S) in the central wheat belt, Katanning (117.58?E, 33.68?S) and Jerramungup (118.82?E, 33.88?S) in the Great Southern and Scadden (121.53?E, 33.47?S) and Salmon Gums (121.67?E, 33.08?S) on the South Coast. All experiments were done using a split plot design with TOS as main plots and cultivars as subplots. All experiments had three replications and TOS were latinised across and within banks. All but two experiments had three TOS. The first TOS was at the earliest available opportunity after the break of the season and subsequent sowings were at 2-3 week intervals.

All experiments were sown using a cone seeder. Plot size was 28.8 m^2. Standard crop management practices including district average fertiliser levels were applied. Grain yield and yield components were recorded as detailed in Sharma and Anderson (2004).

Each experiment was analysed separately for grain yield and yield components using analysis of variance in GenStat$^?$ (2003). The cultivar-specific sowing window was defined by the period when grain yield remained within 10% of the maximum for that cultivar and was calculated from predictions obtained by fitting smoothing splines on cultivar by TOS data in individual trials.

Results

The environments in our study were very diverse and ranged from low rainfall (>250mm growing season rainfall) and rapidly warming sites (e.g. Mullewa) to the cool-finishing environment of the South Coast (e.g. Gibson) where South Australian and Victorian cultivars are often adopted because of their adaptation to this environment. Cultivars Mitre, Annuello and Braewood are some of the successful recent cultivars in southern in contrast to northern environments, where locally-developed Wyalkatchem, Westonia, Calingiri and Carnamah are the currently predominant cultivars (Crop Variety Sowing Guide 2005).

Grain yield differences due to TOS and cultivar x TOS were significant for almost all the trials which was expected given that the set of cultivars tested in these trials were elite cultivars from a range of breeding programs in Australia and New Zealand. These breeding programs seem to have used parents with diverse genetic backgrounds to improve adaptation to the highly diverse wheat growing environments of Australia.

The highest average grain yield for most sites was achieved in certain site-specific calendar periods. For example, at Mukinbudin (low rainfall zone), the late May TOS was always the highest yielding irrespective of the grain yield level which varied from 3.0 t/ha in 2003 to 0.77 t/ha in 2004, suggesting that optimum TOS for the location is around 20 May (Figure 1).

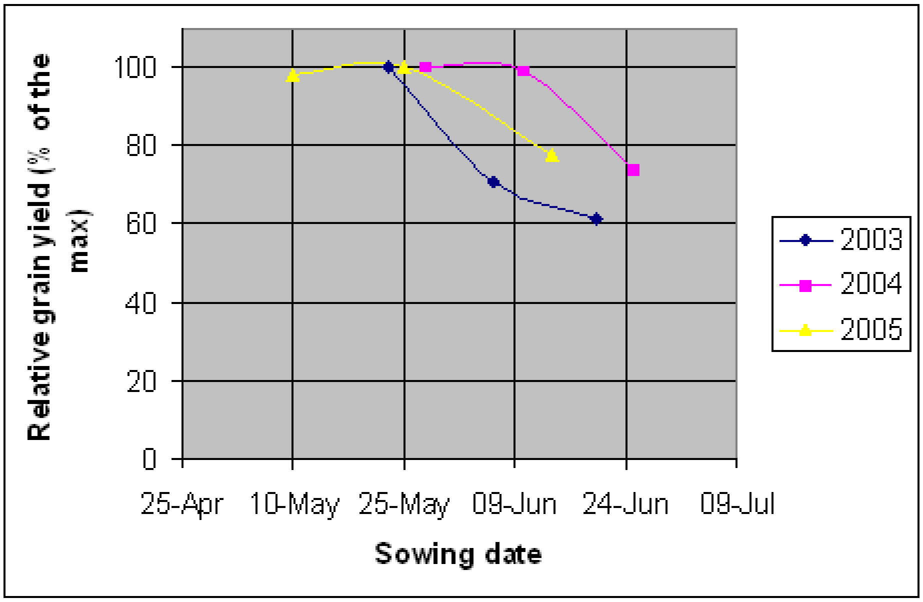

Figure 1. Relative grain yield at three times of sowings in three seasons at Mukinbudin in Western Australia

However, despite the reasonable stability of site-specific sowing windows, individual cultivars differed for the optimum TOS, thus implying that the reliability of estimates of the site-specific sowing window is a function of the range of genetic diversity among test cultivars. For example, at Mukinbudin in 2005, cultivar Carnamah had the highest yield from earlier sowing (20kg/ha/day advantage) in contrast to Wyalkatchem which incurred a significant early sowing penalty of 23kg/ha/day (Figure 2).

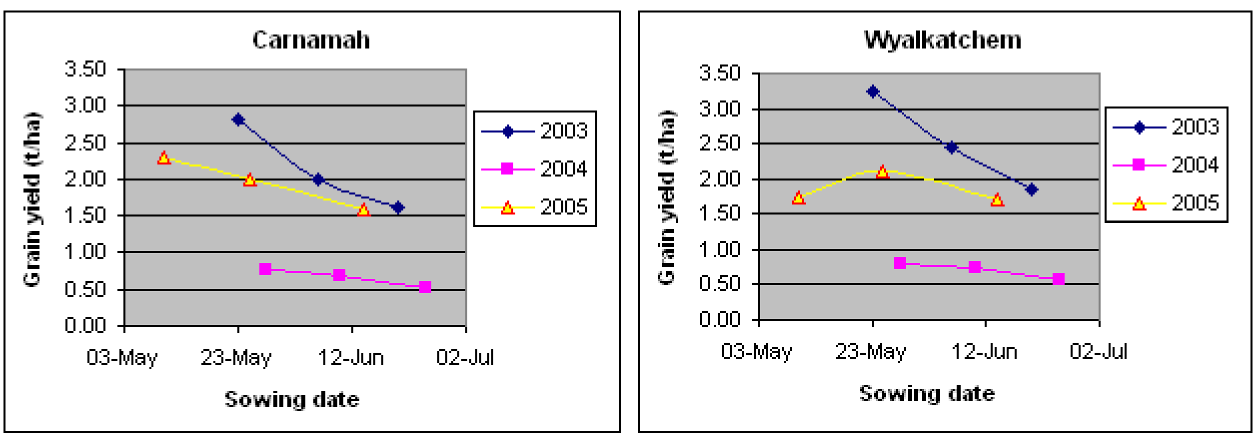

Figure 2. Grain yield of two wheat cultivars at three times of sowing in three seasons at Mukinbudin in Western Australia.

An overall analysis across sites confirmed that early sowing as advocated in earlier work (Delane and Hamblin, 1989; Anderson and Smith, 1990) may not always be true in the context of current cultivars. Early sowing in our experiments clearly demonstrated that cultivars do have optimum sowing dates. Cultivars such as Calingiri (long season) are suited to early sowing, those like Spear (day length sensitive) can be sown early or later provided the season finishes without stress; those like EGA Bonnie

Rock (medium maturity), GBA Sapphire (medium-long season) and Tammarin Rock (early maturity) should not be sown too early (Figure 3). Currently there is a general understanding among WA growers that wheat should be sown as soon as possible after the break but the state-wide data from 2005, the only year in our studies when an early May sowing was possible, show that cultivars need to be matched to the sowing time according to the flowering control and maturity class.

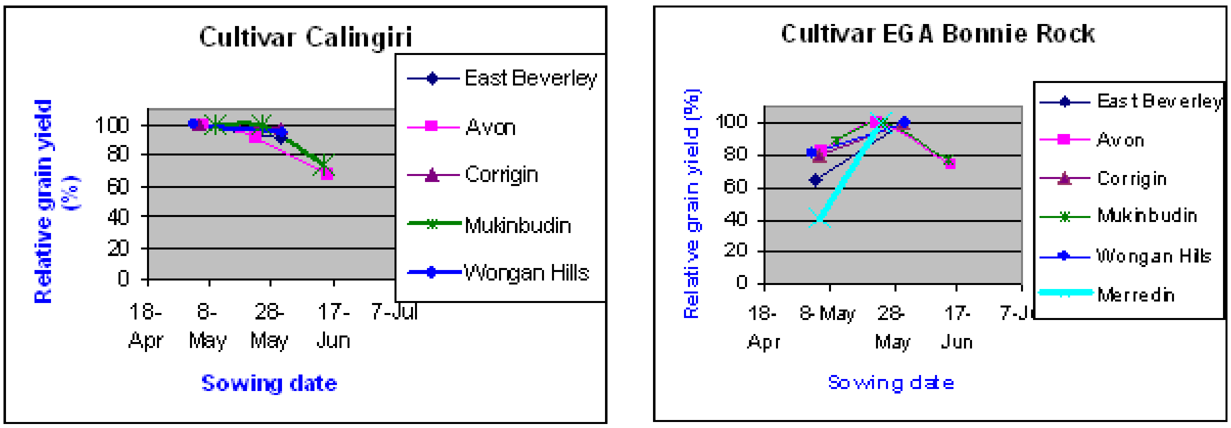

Figure 3. Contrasting yield response to sowing time of a long season cultivar like Calingiri with a short season cultivar like EGA Bonnie Rock in five trials in the Central Region of Western Australia in 2005

On either side of the cultivar-specific optimum sowing window, cultivars differed in the magnitude of the ESP and LSP. The LSP in general was greater than the ESP, and the rate of yield decline with late sowings was more variable among cultivars. This suggested that at Mukinbudin, for example, late sowing conditions not only caused a greater yield decline but also exposed cultivars with inherent weaknesses in coping with short seasons. The ESPs, in the available data set, were relatively small, but significant. It is therefore suggested, that cultivars should be characterised for relative ESP and LSP so that growers can take educated decisions to manage seasonal risk.

Cultivars in the low ESP group were either long season cultivars or have sufficient plasticity of yield components, in contrast to high ESP cultivars which have a medium to short life cycle coupled with low plasticity for yield components (yield component data not presented here).

The range of available data is insufficient for determining seasonal variation of ESPs unless some simulation model is used. However, the LSPs could be calculated with sufficient confidence. Our data suggests that the rate of grain yield decline due to delayed sowing varied with average yield and was generally cultivar specific (Figure 4). However, there were some exceptions in each binary comparison where LSPs for some cultivars were reversed over seasons. For example, at Gibson LSPs were greater in 2003 for all cultivars except EGA Bonnie Rock which had a greater decrease in 2005. We anticipate such differences arise due to cultivar-specific development of yield components in diverse environments. Hence, based upon within site comparisons over years, it appears that cultivars exhibit definite response patterns to delayed sowing and the exceptions from this base response are driven by local site and seasonal factors which could include soil type, crop rotation and soil stored moisture. Appropriate analysis of data to test this hypothesis and define these factors is currently in progress.

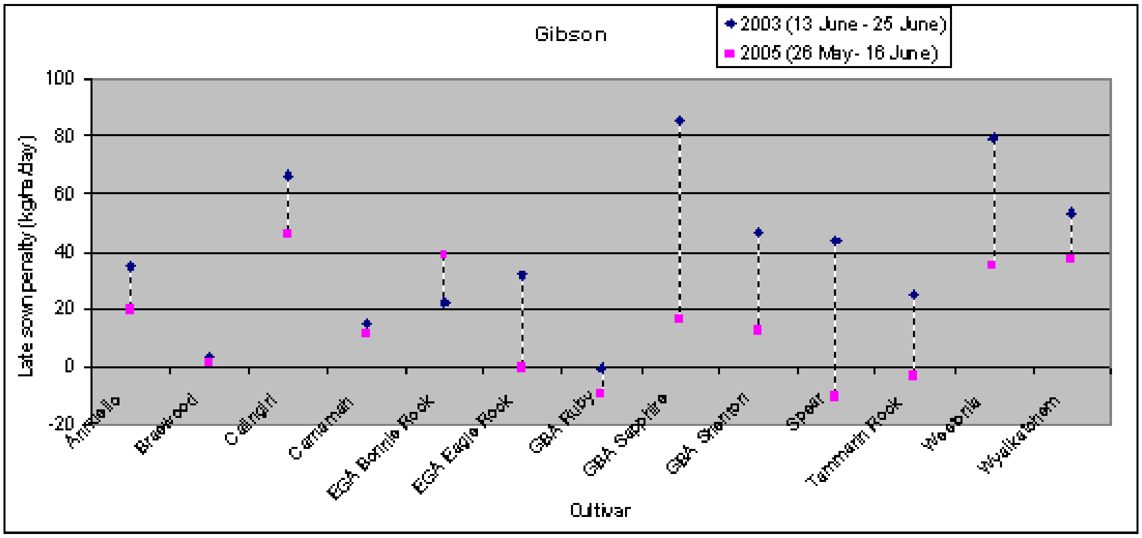

Figure 4. Rate of grain yield decrease in the linear phase after the optimum sowing time of 13 wheat cultivars in two seasons at Gibson in Western Australia.

Conclusion

Matching cultivars to sowing time is still an appropriate strategy, but it should be kept in mind that maturity class can often be overridden by cultivar plasticity to adjust to the season. After further investigation into factors that enable the widening of the sowing window, it should be possible to group cultivars according to response categories and make suggestions for managing seasonal risk with current cultivars.

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