Improving the reliability of early-sown pulses in south-eastern Australia

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Abstract

Sowing of pulses in south-eastern Australia generally occurs between early May and late June depending upon crop type and rainfall, but has typically been delayed compared to cereals, due to agronomic and disease limitations. However, recent seasons in this region have experienced dry and hot springs, making earlier sowing of pulse crops essential in many areas to achieve profitable production. Yields of faba bean, field pea, chickpea and lentil were compared at two or three sowing dates in small-plot field trials conducted across South Australia and Victoria from 2006 to 2009. First sowing ("early") occurred no more than two weeks after first autumn rains. Subsequent sowings ("mid" and/or "late") were at three-week intervals thereafter, representing more traditional sowing dates. Climate, crop growth and grain yield data were recorded. Across 33 experiments at 12 sites, earliest-sown treatments yielded highest in 70% of cases (yield increases were from 7 to 311%). In 18% of cases there was no difference in yield between "early" and later sown treatments. Where lower yields occurred in early-sown treatments (12% of cases) high foliar disease loads and/or high plant biomass were generally observed. Genotype by agronomic management interactions occurred in many trials. Cultivars with better adaptation to earlier sowing were identified. These cultivars, regardless of crop species, generally contained plant traits of lower biomass and improved disease resistance.

Key Words

Sowing date, pulses, yield reliability, faba bean, lentil, field pea, chickpea

Introduction

Determining the optimum sowing date for pulses is complex, being strongly influenced by factors including environment, management system, cultivar and grower attitude to risk. The sowing window for most crops in southern Australia is between late April and July. Faba bean (*Vicia faba*) and lupin (*Lupinus angustifolius*) have traditionally been the earliest-sown pulse crop, generally toward the start of the sowing period, lentil (*Lens culinaris*) and chickpea (*Cicer arietinum*) are sown in the middle of this window, and field pea (*Pisum sativum*) traditionally sown last (Mayfield et al. 2008).

It is generally accepted that early sowing of crops maximises yield potential (Adisarwanto and Knight 1997). However, sowing of many pulse crops in southern Australia is delayed compared to cereals, due to a variety of reasons. These include allowing accumulation of sufficient soil moisture for ideal seed bed preparation, maximising weed germination and control prior to sowing, disease avoidance, frost avoidance during flowering and pod set, avoiding excessive growth associated with lodging and haying off, avoiding damage caused by residual herbicides, and the necessity to fit in with other farming operations and priorities (McMurray et al. 2009). However, delayed sowing often results in grain-yield reductions brought about by compromised plant height and harvestability, and periods of high temperature and moisture stress during flowering and grain filling (Heenan 1994).

Southern Australia has been affected by drought in recent years, with drier and warmer springs, and this has resulted in a shift toward early sowing of pulses. Although early sowing puts the crop at risk of the stresses listed above, it maximises yield potential and has become an important risk management tool in seasons with lower rainfall. This trend has been further encouraged by the release of new cultivars that are better suited to early sowing. This study compares yield of pulse crops at two or three sowing dates and identifies genotypes which can improve the reliability of early sowing in southern Australia.

Methods

Experimental design

Field experiments comparing two or three sowing dates were carried out between 2006 and 2009 in the mid-north (faba bean, field pea, chickpea), Yorke Peninsula (lentil, chickpea) and upper Eyre Peninsula (field pea) regions of South Australia, and the Wimmera (lentil, chickpea) and southern Mallee (field pea, lentil, chickpea) regions of Victoria. Crop types sown were considered optimal for each region. The “early” sowing took place within two weeks of the first autumn rains. “Mid” and “late” sowing dates generally took place at two- to three-week intervals thereafter. Where only two sowing treatments were applied the “late” sowing was performed at three to four weeks after the “early” sowing date.

Experiments were constructed in a split-plot design, using replicate (3) as the main block and sowing date in the sub-blocks. Individual plots were genotype, in interaction with another variable, such as foliar fungicide or plant density. Fertilisers and pesticides were targeted at the current recommended best management practice for each crop type (Mayfield et al. 2008). Hand weeding was also used where required.

Measurements and Analysis

Rainfall, air temperature, soil temperature and humidity were recorded daily by automatic weather stations. All experiments were machine harvested and grain yields recorded. All statistical analyses were conducted using Genstat 12th edition. Grain yields for each sowing date were expressed as percent of site mean to allow for variations in mean site grain yields across sites and years. The percentage site mean data were compared against sowing date using a Multiple Linear Regression with crop type as groups.

Results & Discussion

Climate

Varying post-anthesis moisture stress occurred across all sites from 2006 to 2009 (data not shown), along with above average maximum temperatures in spring (September-November) (data not shown). The Victorian and upper Eyre Peninsula sites incurred the greatest reductions in rainfall compared to long-term average. Annual rainfall between 2006 and 2009 across all sites was up to 49% below the long-term average, with most of the deficit occurring during the growing season (April to October). Growing season rainfall was 43-58% below average across all sites in 2006, 21-45% below average in 2007, and 6-55% below average in 2008. In 2009 only one site experienced below-average growing-season rainfall, however yields were severely reduced at many sites by a severe hot and dry spell in early November that accelerated maturation and suppressed grain-fill. Grain yields were reduced across southern Australia in 2008, most likely due to extensive ‘haying off’ (where crops mature prematurely due to insufficient water availability at the reproductive stage) since very little foliar disease was recorded in most experiments. This was due to a combination of high rainfall and mild temperatures in July-August, promoting vegetative growth (data not shown), and low September-October rainfall combined with sporadic periods of high temperatures, reducing water availability and grain fill.

Sowing Date and Grain Yield

Sowing date was significantly correlated with grain yield ($P<0.01$) in all trials. All pulse crops examined showed a general decrease in yield as sowing was delayed (Figure 1). There was a significant ($P<0.05$) interaction between sowing date and genotype in 30 of the 33 trials (Table 1). An interaction ($P<0.05$) was also observed between sowing date and an agronomic management factor (e.g. plant density, fungicide strategy or row spacing) in 13 of the 33 trials (Table 1). This indicates that further improvements in yield reliability from early sowing may be possible through specific varietal and agronomic manipulation.

Table 1. Trial results summary for each crop type.

Crop	No. Trials	No. trials early sow date yielded highest or equal highest	Yield increase of early sown as a % of late	No. trials Sowing Date x Genotype significant*	No. trials Sowing Date x Management significant*	Yield range (t/ha)
Faba bean	6	5	11 to 65	5	4	0.9 - 4.9
Lentil	11	10	7 to 308	11	3	0.25 - 3.3
Pea	12	11	7 to 311	10	3	0.2 - 2.75
Chickpea	4	3	53 to 273	4	3	0.2 - 1.9

* Significance level P<0.05

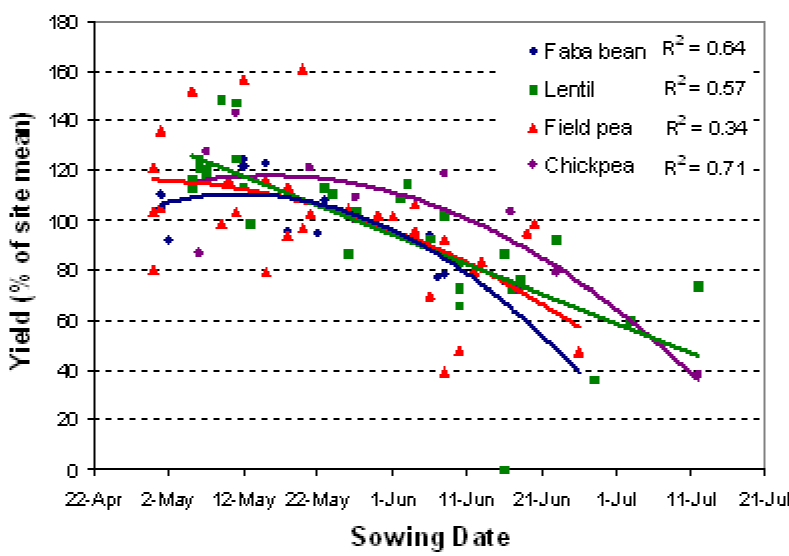

Figure 1. Grain yield (% of site mean) of four winter pulse crops sown on two or three sowing dates at sites across southern Australia from 2006 to 2009.

Early-sown lentil yielded highest or equal highest compared to later-sown lentil in 10 of 11 trials conducted across four years, and yields were 7 to 308% higher than the late sowing date (Table 1). The exception to this trend was at the Yorke Peninsula site in 2008, most likely due to the widespread incidence of ‘haying off’. However genotypic variation was observed. The cultivars Nipper and PBA Flash showed no difference in yield between early- and mid-sown treatments in this experiment, indicating they were better suited to early sowing than other lentil varieties tested e.g. cv. Boomer, which incurred a 25% yield loss at the early sowing date compared to the mid. Nipper is well suited to early sowing dates due to a combination of its dual ascochyta blight (*Ascochyta lentis*) and botrytis grey mould (*Botrytis cinerea* and *Botrytis fabae*) resistances and relative short plant type, reducing disease, lodging and haying off risks, particularly in lentil growing regions more prone to disease.

Field peas showed greater variation between yield loss and sowing delays (Figure 1). This is most likely due to sowing time of field pea in southern Australia being complicated by the interaction with the disease Ascochyta blight. This disease, caused by a complex of fungi (*Didymella pinodes* (synonym: *Mycosphaerella pinodes*), *Phoma medicagini*s var. *pinodella*, *Ascochyta pisi* and *Phoma koolunga* - Davidson et al. 2009), is the most common disease affecting field pea crops in southern Australia (Davidson and Ramsey 2000). Sowing date is traditionally delayed 4-6 weeks after the opening season rains in autumn to minimise yield losses caused by air-borne spores released from the previous season's stubble.

Early-sown field pea yielded highest or equal highest in 11 of 12 trials conducted across four years, with yield increases of 7 to 311% compared to the late (recommended) sowing date (Table 1). However in the SA mid-north site in 2009, severe ascochyta blight spore loads and infection resulted in yield losses in untreated plots compared to plots treated fortnightly with a foliar fungicide at this site (data not shown). However, mid-sown field peas in this trial yielded equal to or higher than late-sown field pea in all varieties except the tall trailing late-maturing cv. Alma, which was found to have higher foliar disease infection levels than recently released earlier maturing semi dwarf type cv. Kaspa and an advanced breeding line (OZP0602) in this trial (data not shown). Yields of these semi-dwarf types in this trial was maximised by sowing 2-3 weeks earlier than currently recommended, even under high ascochyta blight disease infection.

Early-sown faba bean yielded equal or higher than later-sown faba beans in five of the six sowing date trials, with yield increases between 11 and 65% compared to the late sowing date (Table 1). Early sowing has traditionally been recommended for faba beans due to their requirement for a longer growing season than other pulse crops (Adisarwanto and Knight 1997). Faba bean also has more robust seedlings than many other pulse crops and a relatively long imbibition and emergence period, facilitating more effective pre-emergent weed control.

In the trial where early sowing did not yield highest (mid-north SA, 2008), differing cultivar responses were observed and not all varieties performed best when sowing was delayed. As previously described, many crops in 2008 were affected by 'haying off' due to conditions conducive to good plant growth in autumn and winter followed by a shortened and moisture stressed spring period. This resulted in a 20% yield increase by delaying sowing in the tall, later-maturing cultivar Farah (data not shown), but no yield difference was observed in the shorter, mid-maturing cv Nura between the two sowing dates. Its shorter plant type appeared less vulnerable to the conditions responsible for haying off than the taller varieties. Faba bean cultivar Nura has also shown superior disease resistance to other varieties (Egan et al. 2010), and the combination of these features make it a more reliable cultivar for early and dry sowing in southern Australia, particularly in the recent years with dry springs in traditional faba bean growing areas.

Chickpea sown at the early sowing date yielded highest or equal highest in three of four sowing date trials conducted across three years, with yield increases of 53 to 273% compared to the late (recommended) sowing date (Table 1). Where early sowing was lower yielding (Yorke Peninsula, 2008), 'haying off' was observed extensively. However, unlike the other crop species, no genotypic variation for this factor was observed in chickpeas.

Conclusion

All pulse crops in this study showed a general trend of grain yield loss associated with delayed sowing. Early sowing has traditionally been recommended for faba bean, however with the recent number of years with lower than average rainfall, other winter pulse crops are also generally responding positively to sowing earlier than traditionally recommended. A weaker correlation was observed in field pea compared to other crops, as early sowing in field pea is also complicated by disease risks not currently resolved by economic fungicide strategies or improvements in genetic resistance such as has been achieved in lentil and faba bean.

Sowing date by genotype and sowing date by agronomic management interactions indicate that reliability of early sowing could be further improved through careful manipulation of cultivar and agronomic management. Early-sown pulse crops were lower yielding than those sown later in only 12% of situations resulting from either one, or a combination of, high disease intensity and ‘haying off’, caused by excessive biomass production. In two of these four situations, varieties with a relatively shorter plant height such as cv. Nura faba bean and cv. Nipper lentil showed no difference between early- and later-sown treatments unlike other varieties generally characterised by higher biomass levels. With predictions for drier years to continue, and therefore reduced disease risks, earlier sowing of field peas may result in increased grain yield. However, in years where ascochyta blight infection is expected to be high, delayed sowing may be recommended, but potential yields could still be increased over traditional tall, trailing late-maturing types e.g. cv. Alma by using earlier-maturing semi-dwarf types e.g. OZP0602.

Opportunity exists, therefore, for growers to exploit the benefits of early sowing and maximise reliability across years by growing cultivars such as these. Research will be ongoing with the aim of comparing these results in years with higher rainfall and under varying management regimes.

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