Yield and phenology of lentil and faba bean in response to variety and management

RESEARCH

Lachlan Lake, Mariano Cossani and Victor Sadras
SARDI, Waite

Location
Minnipa Agricultural Centre, Paddock N9
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2018 Total: 269 mm
2018 GSR: 208 mm
Yield
Potential: Pulses - 2 t/ha
Actual: 1 to 1.2 t/ha
Paddock History
2017: Wheat
2016: Pasture
2015: Wheat
Soil Type
Loam
Soil Test
Nitrate 16, ammonium 2, sulphur 9.3 (mg/kg)
Plot Size
1 m x 1 m x 3 reps
Trial Design
The trial was a factorial split plot design with sowing date allocated to main plots and variety to subplots
Yield Limiting Factors
Limited rainfall throughout the growing season

Location
Roseworthy
Rainfall
Av. Annual: 400 mm
Av. GSR: 315 mm
2018 Total: 275 mm
2018 GSR: 201 mm
Yield
Potential: Pulses - 5 t/ha
Actual: 1.5 to 2 t/ha
Paddock History
2017: Barley
2016: Canola
2015: Faba bean
Soil Type
Sandy clay loam
Soil Test
Ammonium 15, nitrate 10 (mg/kg)
Plot Size
1 m x 1 m x 3 reps

Key messages

- **Pulses are more vulnerable to stress related yield loss just after flowering at the early podding stage.**
- **In the trials on the upper Eyre Peninsula, Mid North and South East, the risks posed by late sowing, (heat and water stress), outweighed the risks posed by early sowing (frost).**
- **Trends for sowings from mid-April to early July, show that for each days delay in sowing, lentil flowered on average 0.5 days earlier, and yielded 0.5 kg/ha less; faba bean flowered 0.3 days earlier and yielded 0.7 kg/ha less.**
- **Results should be considered in conjunction with grower specific conditions and the trade-off between early sowing, weed and disease management and frost risk.**

Why do the trial?

Lentil and faba bean are moving further into low rainfall areas of South Australia. Pulses are growing in popularity as a result of good prices and rotational benefits such as decreased N input and enhanced grass weed control options. However, frost and combinations of water and heat stress at critical growth stages can compromise crop yield. Previous work in pulses has established that the most important time to maintain growth and limit stress is the period around pod set. Sowing date and variety choice are the two main tools to manipulate time of flowering and pod-set, and thus manage the risk of extreme temperatures, water stress and the trade-off between frost and heat risk.

The aim of this work is to determine the best management practices to avoid stress and maximise yield of lentil and faba bean. We analysed the impact of sowing date and variety on the phenology and grain yield of lentil and faba bean across different South Australian cropping environments, including the upper Eyre Peninsula.

This is the third year of trials previously reported in EPFS Summary 2017, p 146 and 2016, p 62.

How was it done?

Field trials have been conducted at Minnipa Agricultural Centre (2016, 2017 and 2018), Hart (2016), Roseworthy (2017 and 2018), Bool Lagoon (2016 and 2017) and Conmurra (2018) to test the effect of sowing date on phenology and yield of lentil and faba bean varieties. The trials combined six sowing dates ranging from 20 April to 11 July, with ten varieties of each crop chosen in consultation with breeders and industry experts. Faba bean varieties included Icarus, AF03001-1, PBA Rana, PBA Samira, Farah, PBA Zahra, Aquadulce, 91-69, Fiord, and Nura. Lentil varieties were PBA Blitz, Northfield, CIPAL901, CIPAL1301, PBA HurricaneXT, PBA Hallmark XT, PBA Giant, PBA Jumbo2, Nugget and Matilda.

Trial Design
As above
Yield Limiting Factors
Limited rainfall throughout the growing season

Location
Conmurra - SARDI Straun
Rainfall
Av. Annual: 650 mm
Av. GSR: 490 mm
2018 Total: 709 mm
2018 GSR: 570 mm
Yield
Potential: Pulses - 5 t/ha
Actual: 3 t/ha
Paddock History
2017: Faba bean
2016: Cereal
2015: Cereal
Soil Type
Black clay loam
Soil Test
Ammonium 5, nitrate 35, sulphur 9 (mg/kg)
Plot Size
1 m x 1 m x 3 reps
Trial Design
As above
Yield Limiting Factors
Some accidental herbicide damage limited yield

For each species at each location, three replications were sown for each genotype and sowing date. Crops were sown by hand in a split-plot design with sowing dates allocated to the main plot and varieties randomized within each subplot. Plot size was 1 m by 1 m and consisted of 3 rows, 0.27 m apart. Density was 60 (faba bean) and 120 (lentil) plants per square metre. Prior to sowing, P was supplied by applying 80 kg/ha of MAP. During the growing season, we measured phenology twice weekly within the central rows of the plots. We recorded the date when 50% of plants within the central row had reached: flowering, pod emergence, end of flowering and maturity.

At Minnipa (2016, 2017, 2018) and Roseworthy (2017, 2018), yield was measured from a subsample of 0.5 m length from the central rows of all plots. Samples were dried at 70°C until constant weight was achieved and then grains were separated from the pods, cleaned, counted and weighed. Data was analysed using Sigmaplot 14.0 and R.

What happened?

The general trends in phenology have been consistent across environments with time to flowering and podding decreasing with delayed sowing (Figure 2); temperature and day length are the primary influences on phenology with later sown crops experiencing longer warmer days. The differences for time from sowing to flowering and pod emergence across environments is presented in Table 1. Faba bean tended to flower earlier than lentil, however took longer from flowering to pod set (Table 2). For every ten days delay in sowing, there was an associated loss of five days vegetative growth for lentil and three for faba bean.

As with time to flowering and pod emergence, yield showed a decline with delayed sowing when considering all locations (Figure 1), however we found that the relationship differed between species, years and locations (Figure 2).

Table 1 Variation in time (days) from sowing to flowering in lentil and faba bean varieties

Beans	Mean	Minimum	Maximum	Lentils	Mean	Minimum	Maximum
AF03001-1	76	51	117	PBABlitz	93	71	138
Fiord	78	55	93	CIPAL901	95	71	138
AF009169	80	57	146	PBAGiant	97	72	142
Farah	81	57	125	PBAJumbo2	98	71	146
PBAZahra	84	59	113	CIPAL1301	99	76	149
PBARana	85	60	110	PBAHallmarkXT	100	71	150
Nura	85	61	115	PBAHurricaneXT	101	77	150
PBASamira	86	60	116	Matilda	103	73	149
Aquadulce	88	59	122	Nugget	104	76	150
Icarus	98	66	133	Northfield	109	82	170

Table 2 Variation in time (days) from sowing to pod emergence in lentil and faba bean varieties

Beans	Mean	Minimum	Maximum	Lentils	Mean	Minimum	Maximum
Fiord	90	63	108	PBABlitz	98	78	123
AF03001-1	90	59	129	CIPAL901	100	81	134
AF009169	92	66	111	PBAGiant	101	80	126
Farah	94	64	114	PBAJumbo2	102	81	127
Nura	96	67	116	PBAHallmarkXT	103	80	135
PBARana	96	70	115	CIPAL1301	104	83	134
PBAZahra	96	70	120	PBAHurricaneXT	105	84	135
PBASamira	97	69	121	Matilda	108	84	132
Aquadulce	103	74	131	Nugget	109	84	137
Icarus	104	74	127	Northfield	112	88	143

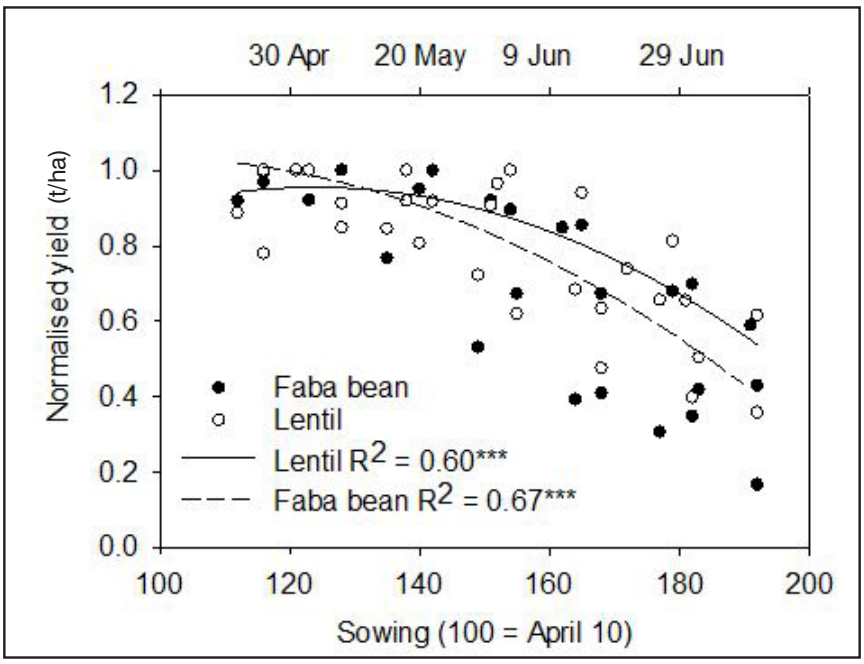

Figure 1 Yield penalty as a function of sowing delay from April 22. Yield is presented as a proportion of maximum attainable yield for each location x season combination. There were five location x season combinations each with six times of sowing. Lines are polynomial regressions.

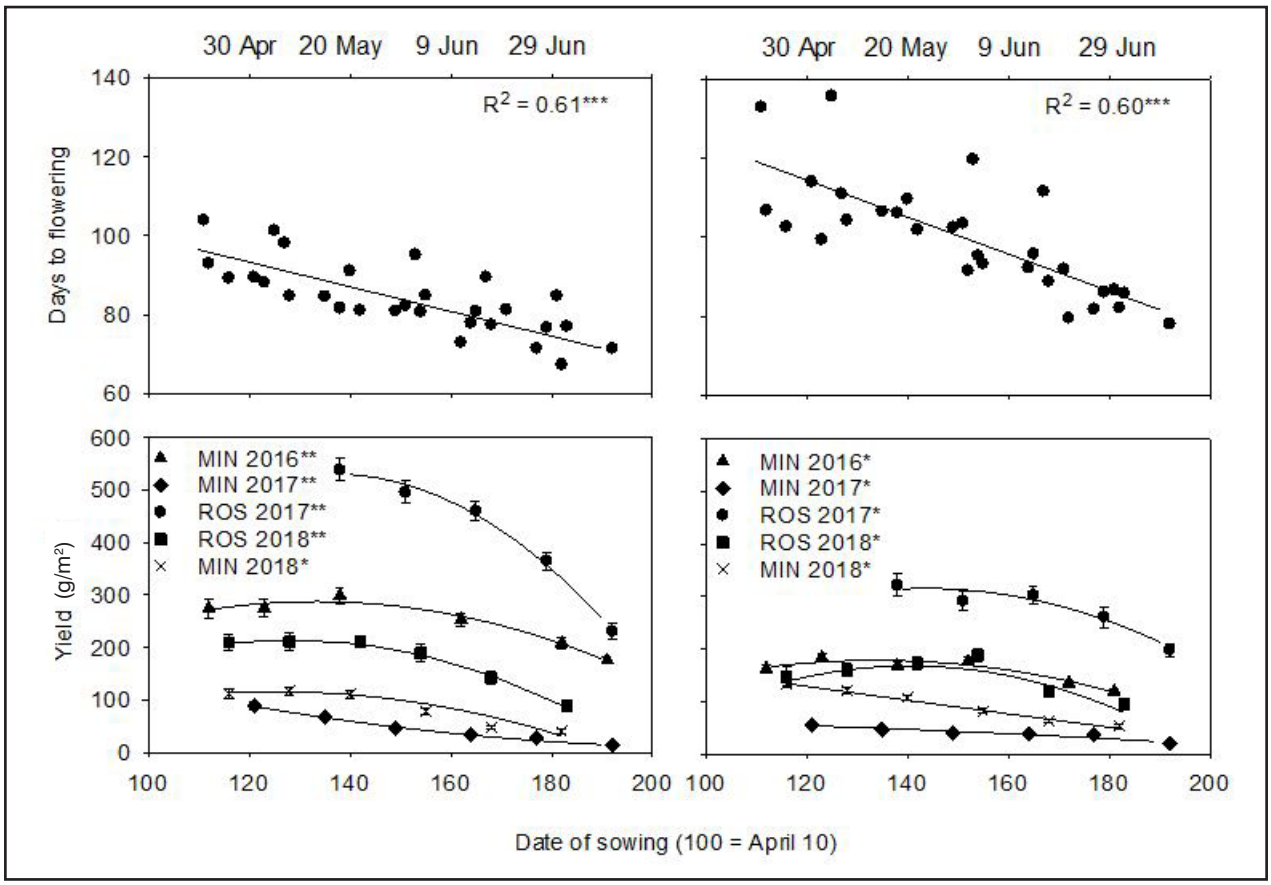

Figure 2 Phenology (top panels) and grain yield (bottom panels) of faba bean (left panels) and lentil (right panels) as a function of sowing date. Yield has been separated by environment while phenology is pooled across environments. Significance is denoted as P<0.05*, P<0.01** and P<0.001.***

When considering specific locations, yield losses could be incurred from any delay in sowing such as faba bean at Minnipa in 2017 and lentil at Minnipa in 2017 and 2018. However it was also common to see losses only after mid May (Figure 1 & 2). Across all environments, and for every ten days delay in sowing of faba bean from 20 April there was an associated loss of 7% of maximum yield while for lentil that value was 5% (Figure 1). Using 2018 data for Minnipa, this represents a loss in terms of gross margins of $20/ha or 10% for lentil and $19/ha or 14% for faba bean.

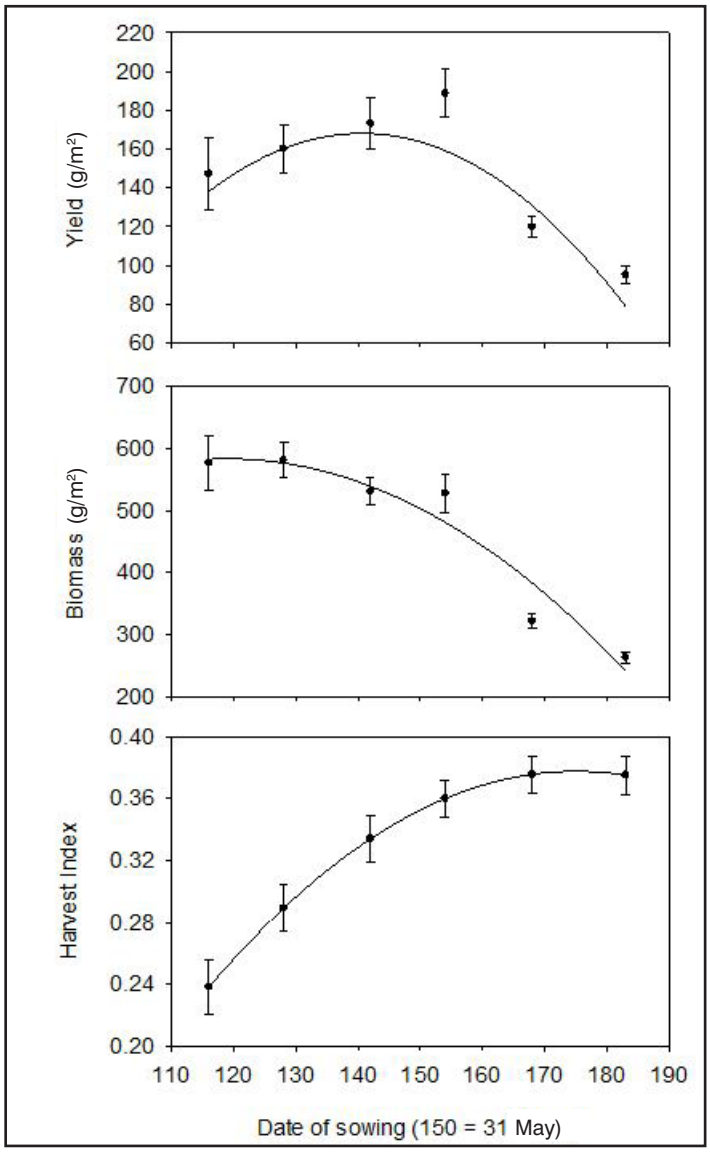

Figure 3 Effect of sowing date on lentil yield and components at Roseworthy 2018

Yield losses were higher in higher yielding environments but proportionally higher in lower yielding environments. The largest faba bean yield reductions were over 2.5 t/ha at Roseworthy in 2017 with a delay in sowing from 18 May to 11 July, while in the lowest yielding environment (Minnipa 2017) the yield loss was lower at 0.74 t/ha with a delay from 1 March to 11 July; this represents a loss of almost 85%. For lentil, the yield penalty associated with delayed sowing was smaller with more variation between locations; the largest loss was at Roseworthy in 2017 with 1.3 t/ha lost with a delay from 18 May to 11 July, while in the lowest yielding environment of Minnipa in 2018 the loss was 0.5 t/ha or nearly 65% when sowing was delayed from 27 April to 3 July.

Figure 3 demonstrates that in some instances for lentil, early sowing may lead to a yield penalty. In this instance the first and second times of sowing yielding significantly less than the fourth time of sowing ($P<0.05$). This yield loss was incurred at Roseworthy 2018 and was most likely due to excessive canopy growth with low harvest index. The relatively dry season may have resulted in the higher biomass canopies from early sowing to suffer from moisture stress later in the season, failing to convert potential yield into actual yield.

What does this mean?

The yield of both lentil and faba bean are significantly reduced when sowing is delayed past the optimal sowing date which varies for location and rainfall. In low rainfall environments such as Minnipa, optimal sowing tended to be as early as possible, while in the medium to higher rainfall areas, the middle of May was better. The yield penalty associated with delayed sowing is a result of a shorter time to flowering and podset, caused by accelerated development. This has a negative effect on potential yield resulting in reduced seed set, particularly in good years and environments. The other factor reducing yield was delayed sowing pushing the reproductive window further toward hot dry conditions that also hasten phenological development and limit yield. On average, the penalty for faba beans was 7% of their maximum yield per 10 days that sowing was delayed after 20 April, and 5% for lentil.

The genetic variability in phenology of both lentil and faba bean can be used by growers who wish to target a specific growth window to avoid both frost and heat stress, whilst maximising yield. However, in the absence of severe frost, sowing before the middle of May will be more likely to provide the maximum yield for the location whilst allowing some flexibility in the system for other factors such as soil moisture, weed and disease control.

Acknowledgements

Special thanks are given to Brenton Spriggs, Sue Budarick, Amanda Pearce and Annabel O'Dea for their collaboration with field and lab activities. This project is funded by and part of GRDC-SARDI Bilateral DAS 00166.

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE