Managing frost and heat in lentil and faba bean

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Location
Minnipa Agricultural Centre, Paddock N9
Rainfall
Av. Annual: 324 mm
Av. GSR: 241 mm
2018 Total: 239 mm
2018 GSR: 176 mm
Yield
Potential: Pulses - 2 t/ha
Actual: 1 to 1.2 t/ha
Paddock history
2017: Wheat
2016: Pasture
2015: Wheat
Soil type
Clay 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 yield loss from heat and frost stress in a critical period centred around early podding.**
- **Sowing time and variety choice are crucial to reduce risk of stress at this stage.**
- **We define the safer window for the critical period as less than 10% chance of frost (0°C in the Stevenson screen) and less than 30% chance of heat (>34°C in the Stevenson screen).**
- **In environments of upper Eyre Peninsula, such as Minnipa, there is limited frost risk, hence early sowing will minimise heat risk and maximise potential yield.**
- **However, at sites such as Laura (Mid North), there is a safer window after frost and before heat.**
- **Results should be considered in conjunction with grower specific conditions and the trade-off between early sowing, weed and disease management and rainfall.**

Why do the trial?

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.

This research aims to identify the safer temperature windows for the critical period for yield for faba bean and lentil in cropping regions of southern Australia. This work follows on from EPFS Summary 2016 p62, EPFS Summary 2017, p146 and EPFS Summary 2018, p62.

How was it done?

Field trials have been conducted at Minnipa Agricultural Centre (2016-18), Hart (2016), Roseworthy (2017-18), Bool Lagoon (2016-17) and Conmurra (2018) to test the effect of sowing date on phenology and yield of lentil and faba bean varieties. We 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.

For each species at each location, three replications were sown for each variety and sowing date. Crops were sown by hand in a split-plot design with sowing dates allocated to the main plot and

Trial design
As above
Yield limiting factors
Limited rainfall throughout the growing season

Location
Conmurra
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

varieties randomized within each subplot. Plot size was 1 m^2 and consisted of 3 rows, 0.27 m apart. Density was 60 plants/m^2 (faba bean) and 120 plants/m^2 (lentil). Prior to sowing, P was supplied by applying 80 kg/ha of MAP (10:22:0:0). During the growing season, we measured phenology twice weekly within the central rows of the plots. We recorded emergence and the date when 50% of plants within the central row show the first appearance of: flowers, pods, end of flowering and maturity.

Phenology data was then used to calibrate and validate APSIM (Figure 1). The model was used with historical weather data to simulate flowering date for early, mid and later flowering varieties across 61 years and nine sowing dates ranging from 1 April to 1 August. We use 200°Cd (degree days) after flowering as the critical period.

What happened?

Lentil data is still being analysed so only the faba bean data is presented. The observed data was matched to the simulated data explaining more than 87% of the variability (Figure 1) providing a reliable tool to predict flowering across varieties, sowing dates, years and environments. In agreement with observations, modelling showed that delayed sowing reduced the length of phenological phases and reduced the spread of the critical period (Figure 2 bottom panels).

The safer window for the critical period ranged from before 9 October in Minnipa, and between 1 September and 27 October in Laura (Figure 2).

Due to the low frost risk at Minnipa, sowing any variety before 15 July hits the safer window. However, at sites such as Laura where spring frosts are a risk, but the onset of heat occurs later in spring, sowing needs to be later than 1 May (or with PBA Samira on 1 May) and can be as late as 30 July.

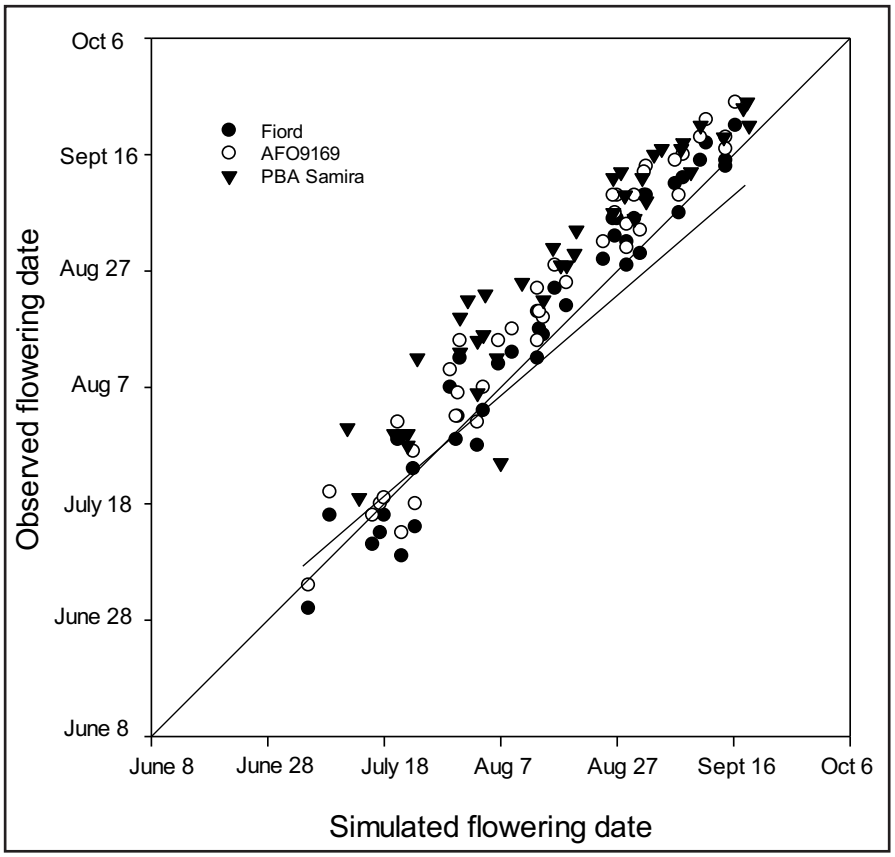

Figure 1. Comparison of observed and simulated flowering date for three faba bean varieties. The solid line is the 1:1 line representing perfect agreement, while the shorter line is a reduced major axis (RMA) regression done with IRENE. R^2 for the individual regressions are: Fiord 0.91, PBA Samira 0.87 and AFO9169 0.95.

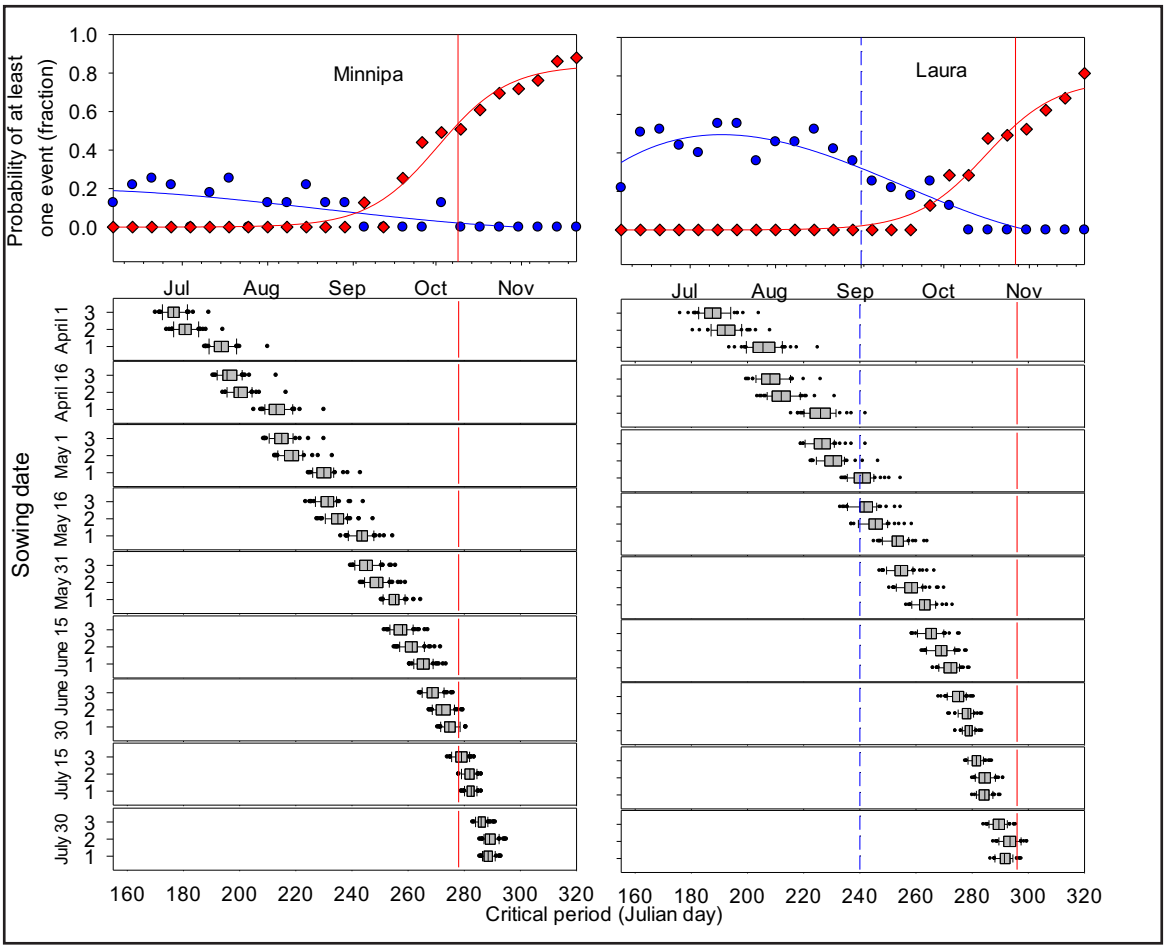

Figure 2. Weekly probability of experiencing at least one frost (circles) or heat event (diamonds) (top panels), and the critical period for three faba bean varieties (bottom panels) with sowing dates ranging from 1 April to 30 July. Varieties are Fiord, PBA Samira and AFO9169. Probabilities have been square root transformed (e.g. take the square root of the probability) in order for the models to best describe the data. For Minnipa the safer window is before the 30% heat risk (solid line), while for Laura the safer window is between the dashed line (10% frost risk) and the solid line (30% heat risk). Note Minnipa does not reach 10% frost risk, hence no dashed line.

What does this mean?

The genetic variability in phenology of both lentil and faba bean coupled with sowing date, can be strategically used by growers to target a specific safer window that reduces likelihood of both frost and heat stress. In the absence of severe frost, sowing before the middle of May will be more likely to provide the maximum yield for drier locations of upper Eyre Peninsula such as Minnipa, whilst allowing some flexibility in the system for other factors such as soil moisture, weed and disease control. In cooler environments delayed sowing is necessary to avoid damage from frost in the critical period. Results for lentil and a wider range of environments for faba bean will be made available later in 2020.

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