Impact of sowing date on phenology and yield of lentil and faba bean

C. Mariano Cossani[1, 2], Larn McMurray[3], Lachlan Lake[2] and Victor O. Sadras[2]

[1] SARDI, 1 Hindmarsh St, Port Lincoln, SA 5606, mariano.cossani@sa.gov.au
[2] SARDI, Waite Building 11a Hartley Grove, Adelaide, SA 5001
[3] SARDI, Clare, SA 5453

Abstract
The use of faba beans and lentils in crop rotations of South Australia has become an attractive option to break cereals and improves the sustainability of the farming system by providing organic nitrogen into the soil. An improved understanding of the genotypic variability in the response of both crops to common farmer management practices such as sowing date is a priority to maximise profits through better targeting of varieties to environment. This study analysed the response of ten varieties of lentils and faba beans to six different sowing dates in the Upper Eyre Peninsula, South Australia. The main objective was to understand the impact of sowing date on phenological development and the resulting effect on grain yield and yield components. In general, the later sowing dates reduced grain number per square meter and produced lower thousand kernel weight. The reductions in grain size, however, were always consistent with the increase in the delay of sowing.

Keywords
Pulses, yield components.

Introduction
The use of pulse crops in farming systems enhances the sustainability and efficiency of agricultural production through increased soil N levels mediated by N_2 fixation, increased rotation and weed management option, disease breakdown, and improvement of soil physical properties in Mediterranean regions including South Australia. Faba bean (*Vicia faba* L.) and lentil (*Lens culinaris* ssp. culinaris Medik.) are two important pulse crops with growing interest from farmers in low rainfall areas of South Australia. These crops have potential to spread to new regions of the Eyre Peninsula and other non-traditional growing regions of South Australia, due to increased grower interest driven by recent high prices of lentils coupled with their rotational benefits; however abiotic stresses such as frost and heat stress can compromise performance and crop yield.

Crop phenology integrates climate signals over a sustained period and is easily measured. For instance, the timing of flowering, duration of grain filling, or time to maturity are key components considering the time and resource limitations imposed on crops and can be affected as a consequence of changes in sowing time. Knowing how local crop management practices modify the key phenological stages is a key step for providing farmer recommendations to target specific environments. Although many improvements have been made in pulse crops during the last decades, improved frost and heat tolerance were recognised as the next challenges for pulse breeding (Siddique et al. 2013). The use of genotypic variability and the understanding of the genotype by environment interaction is a key step for reducing yield gaps of pulses. Therefore, the aim of the present study was to assess and understand the response of faba bean and lentil to changes in sowing date and genotypic variability in key phenological traits.

Methods
A field trial was set up at Minnipa Agricultural Centre, Minnipa, Eyre Peninsula, South Australia during 2016 including a combination of sowing dates and different varieties of lentil and faba bean. The sowing date treatment consisted of six sequential sowing dates, beginning on the 21st April and ending on the 26th of June; sowing dates were intended to cover the complete range of sowing options for the area. The genotype treatment consisted of ten varieties of each crop which were chosen in consultation with Pulse Breeding Australia's lentil and faba bean programs. Faba bean varieties were 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 Hurricane XT, CIPAL1422, PBA Giant, PBA Jumbo2, Nugget, and Matilda. Crops were hand sown in a split-plot design with sowing dates allocated to the main plot and genotypes randomised within each of them. In both crops, three replications for each genotype and sowing

date were used. Plot size was 1 m by 1 m and consisted of 3 rows, 0.27 m apart. Before sowing, phosphorous was applied using 60 kg/ha of MAP (11:22:0:0).

Within each experimental unit, ten plants were selected and tagged in a representative area, trying to avoid the border effect. During the growing season, an intensive assessment of each plant's phenology was measured every 2 - 3 days during the peak season (when flowering and podding was overlapped) and 3 - 4 days out of the peak season. The traits evaluated were; the beginning of flowering, the beginning of podding, node of the first flower, the node of first pod, the end of flowering, and maturity date. After maturity, a subsample of 0.5 m length was hand-collected and dried in an oven at 70℃ until constant weight was achieved. Grains were separated from the pods, cleaned, counted and weighed. The grains per shoot were also counted in the faba bean samples.

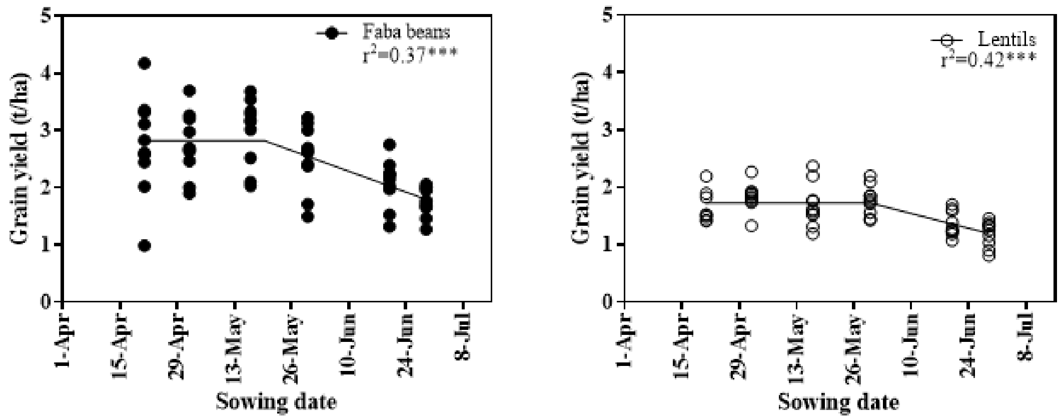

Figure 1. Grain yield of faba bean varieties (left panel) and lentil varieties (right panel) as a function of sowing date at Minnipa in 2016. * indicates P<0.001.**

Results

Sowing date and genotype produced a significant effect on the yield and phenology of faba bean and lentil. In general, grain yield decreased with the delay of sowing (Figure 1) although the effect was only significant after 20 May. The highest variability in grain yield of faba bean was observed for the earliest sowing date and was mostly due to the poor yield of the late maturing broad bean variety Aquadulce. The grain yield of faba bean averaged across varieties ranged between 2.98 t/ha at the sowing date of 17 May to 1.76 t/ha in late June. The highest grain yield of faba beans (4.17 t/ha) was observed when sowing Nura on 21 April while Aquadulce obtained the lowest yield in the latest sowing (1.27 t/ha). For lentils, the highest grain yield was 2.37 t/ha for CIPAL1301 sown on 17 May, while the lowest was for late-sown Northfield (0.81 t/ha) on the 26 of June.

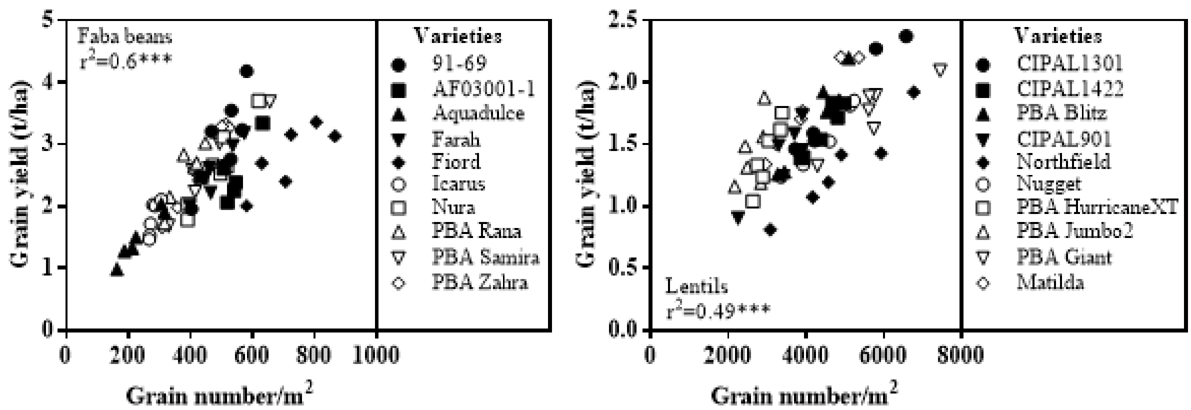

Figure 2. Grain yield of faba beans (left panel) and lentils (right panel) as a function of grain number/m^2 for all sowing dates and varieties at Minnipa in 2016. * indicates P<0.001.**

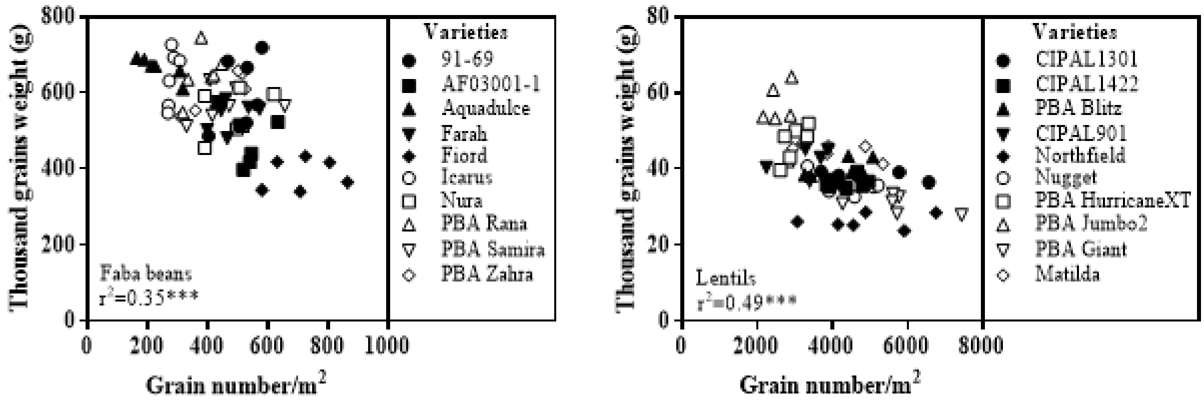

Figure 3. Thousand grain weight as a function of the grain number/m^2 of faba bean (left panel) and lentil (right panel) for all sowing dates and varieties at Minnipa in 2016. * indicates P<0.001.**

In both cases, grain yield was positively related to grain number per unit area (Figure 2) and unrelated to thousand grain weight. In general grain number per unit area (m^2) explained *ca.* 50% or more of the variation in grain yield. The range of variation of grain number was from 163 to 864 grains/m^2 for faba bean and 2163 to 7440 grains/m^2 for lentil. There was a negative relationship between the grain number/m^2 and the thousand grain weight of the two crops (Figure 3). However, the relationship was not significant for most of the genotypes independently, indicating a dominance of genotypic effect on this relationship rather than an environmental effect.

Delaying sowing advanced flowering and podding in both crops (Figure 4). In faba bean, podding time was advanced more (0.48 days to podding per day delayed in sowing) than flowering time (0.31 days to flowering per day delayed sowing). Lentils showed a similar reduction of about 0.4 days to flowering or podding per delayed day in sowing, (Figure 4). Delaying sowing after 21 April, produced an average effect on both crops of 1 day reduction in the days to podding for every two days of delay in sowing. Furthermore, there was an average negative effect of sowing date by shortening the growing season at a rate of 5 days per week that sowing date was postponed after 21st April.

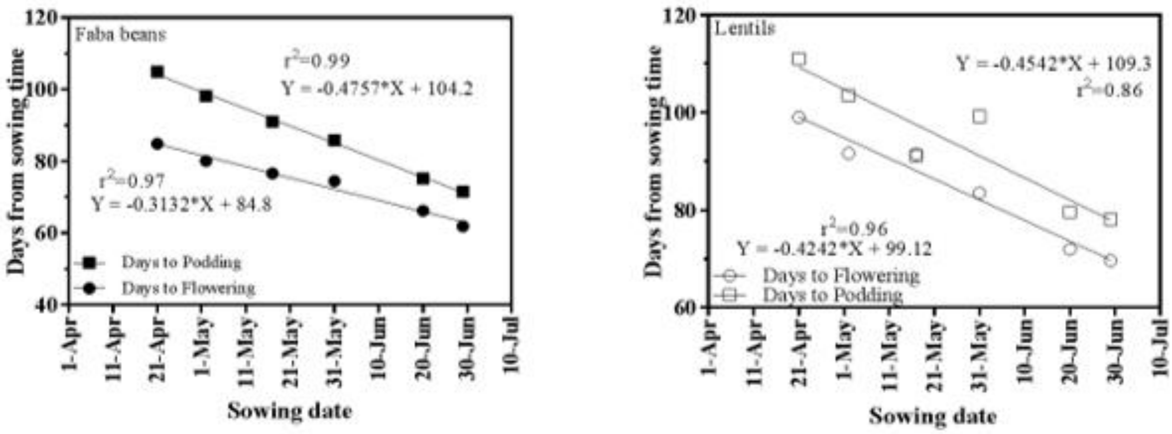

Figure 4. Average effect of sowing date on the phenology of faba bean (left panel) and lentil (right panel) for all sowing dates and varieties at Minnipa in 2016. Squares represent days to podding while circles symbols represent days to flowering.

Conclusions

First of all, a note of caution regarding the exceptional cropping conditions in 2016. During 2016, Minnipa experienced 27% more rainfall from April to October, with an additional benefit of lower (20%) average minimum and (5%) maximum temperatures from August to November. These exceptional conditions could have a confounding effect of underestimating the negative impact of the environmental conditions on the relationship between the traits and main treatments or the interaction between them. Considering this, our results accurately characterise the main effects of delaying sowing on the variability of the phenology and yield of faba bean and lentil. The yield of both crops decreased in general when delaying sowing, however, the effect was more pronounced from intermediate sowing dates (Mid may) onwards. Main yield penalties were the consequence of changes in the crop phenology which consequently affected main yield components. In general, the later sowing dates reduced grain number per square meter and produced lower thousand kernel weight. The reductions in grain size, however, were always consistent with the increase in the delay of sowing.

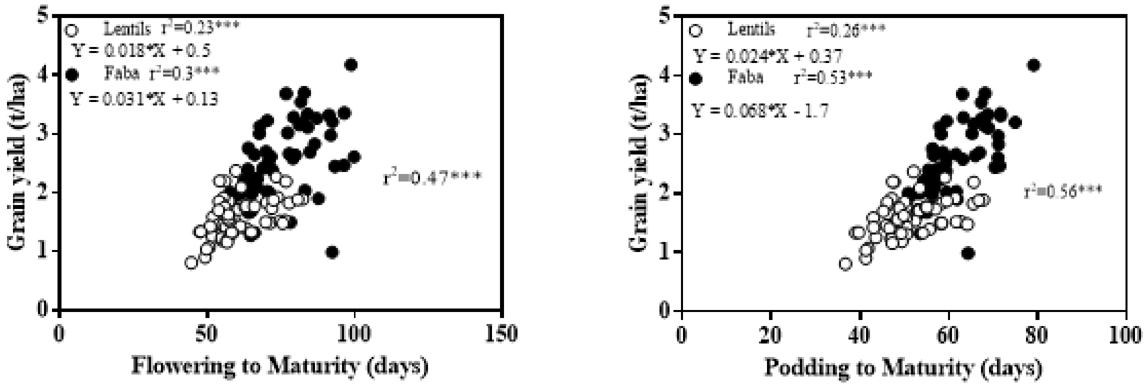

Figure 5. Average effect of sowing date on the phenology of faba beans (left panel) and lentils (right panel) for all sowing dates and varieties at Minnipa in 2016. * indicates P<0.001.**

Regarding the very early sowing dates, both crops experienced a reduction in grain number per unit area, which was partially compensated by heavier grains (Figure 6).

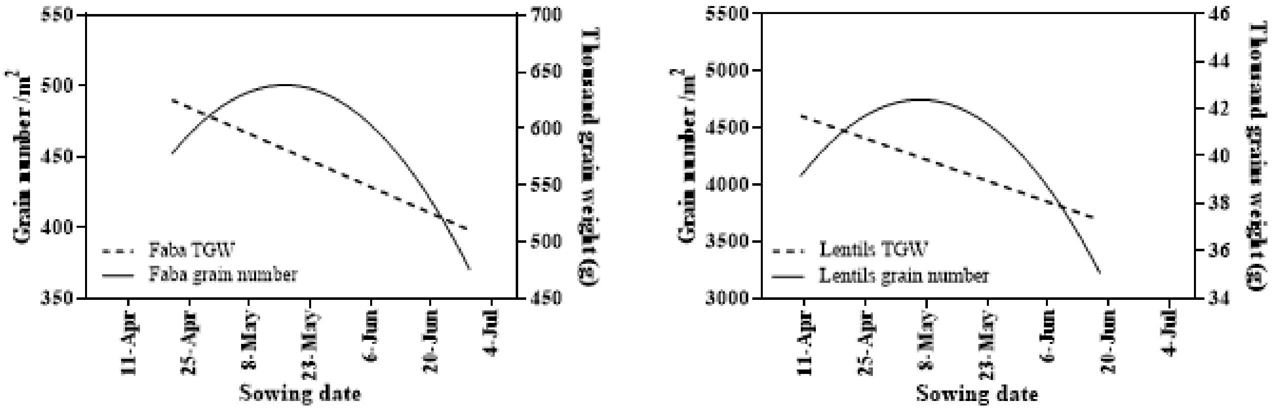

Figure 6. Estimated effect of sowing date on grain number/m² (left Y axis) and thousand grain weight (right Y axis) in faba beans (left panel) and lentils (right panel) at Minnipa in 2016.

Previous lentil studies in south-western Australia (Siddique et al.1998) indicated a yield penalty between 4 and 29 kg/ha/day as a consequence of delaying sowing time. Our results indicate a decrease of around 120 kg/ha/delayed day from 31 May onwards for the case of lentils, and 180 kg/ha/delayed from approximately 20 of May onwards for the case of faba beans. However, values cannot be directly compared due to differences in the varieties, locations, exceptional environmental conditions, and different estimation method of penalties. Additional data is required to determine with higher reliability the yield penalty associated with delayed sowing.

References

Siddique KHM, Erskine W, Hobson K, Knights E, Leonforte A, Khan TN, Paull JG, Redden R and Materne M (2013). Cool-season grain legume improvement in Australia - Use of genetic resources. Crop and Pasture Science 64, 347-360.

Siddique KHM, Loss SP, Pritchard DL, Regan KL, Tennant D, Jettner RL and Wilkinson D (1998). Adaptation of lentil (Lens culinaris Medik.) to Mediterranean-type environments: Effect of time of sowing on growth, yield, and water use. Australian Journal of Agricultural Research 49, 613-626.