Flipping the script on the 'failure bean' story: faba bean out-yielding in early sowing opportunities

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Abstract
Delayed sowing often results in reduced grain yield due to lower biomass production and reproductive development occurring in periods of heat and moisture stress. Producers in the southern region of Australia are sowing crops earlier to adapt to changes in rainfall patterns, a reduction in frequency and magnitude of autumn break rainfall events, weather extremes during spring and increasing farm size. Trials were sown with several faba bean varieties differing in maturity characteristics across multiple sowing times in contrasting environments from 2015 to 2020. Yield increases of 0.05 to 1.9 t/ha were achieved from early sown faba beans. These increases were strongly varietal and rainfall dependent. There was large variation in grain yield response to time of sowing (ToS), however, this was dependent on the type of rainfall environment. An understanding of the effect of variety selection, ToS, and their interaction on faba bean grain yield response will allow growers to optimise their sowing programs to achieve maximum yield potential.

Keywords
Pulse, adaptation, flowering window, opportunistic, growing season

Introduction
Faba bean production in South Australia (SA) currently accounts for 20% of total cropping area sown to pulses in the state, equating to 135 kt in total production (ABARES, 2020). The industry first commenced in SA in 1981 with the release of the variety Fiord, later expanding to the higher-rainfall cropping regions of Victoria, New South Wales and Western Australia (GRDC, 2017). It was during this early period of adoption, along with early released varieties including Fiord, Barkool and Fiesta, that faba bean earnt a negative reputation and was dubbed 'failure beans' by unapproving growers (Onus, 2014). The reason for this apprehensive approach to growing faba bean came down to the poor disease resistance of early varieties and their performance under wet seasonal conditions, where they would potentially be decimated by chocolate spot and/or rust (McMurray et al., 2009). In recent years, the stigma of growing faba bean has receded, primarily due to increases in disease resistance, reduced susceptibility to lodging, and varietal improvements in agronomic performance specific to rainfall environment. The improvement in more desirable traits delivered via breeding, accompanied with the indeterminate characteristics of faba bean, has led to sowing these crops earlier than they normally would in certain regions, particularly low to medium rainfall environments (Walela et al., 2016). Conventionally, the sowing of most pulse crops is delayed to avoid pressures from high disease incidence, flowering, podding and grain fill occurring during periods of high frost risk, increased weed competition, and to also reduce excessive growth that can lead to premature lodging, shading and smothering. However, delaying sowing often results in a yield reduction due to less growth and dry matter production, and flowering and grain fill occurring during periods of increased temperatures and moisture stress (Gaynor et al., 2009).

Research investigating the effect of time of sowing (ToS) on varietal performance under different environmental conditions throughout the Mid-North of SA was conducted across four seasons of trial research, over a six-year timeframe (2015-2017, 2020). The purpose of this research was to determine the suitability of the opportunistic early sowing of faba bean in this growing region, in order to extend the growing season and boost the yield potential of this commodity, with the aim of increasing overall crop performance and return to growers.

Methods

Research trials were undertaken from 2015-2017 at Hart (medium-rainfall zone) in the Mid-North, SA, and in 2020 at Warnertown (low-rainfall zone) in the Mid-North, and Wudinna (low-rainfall zone) and Tooligie (medium-rainfall zone) on the Eyre Peninsula. At Hart, trials were generally dry sown in mid-April with two subsequent delays in sowing, 3-4 weeks apart (Table 1). Twenty millimetres of rainfall equivalent supplementary irrigation was applied immediately post-April sowing only in 2016 and 2017, while subsequent times of sowing had ample moisture to stimulate germination. Field trials in 2020 were sown at the beginning of April and beginning of May, with 20 mm of supplementary irrigation applied immediately post-April sowing, and pre-May sowing within a couple days to simulate a singular rainfall event.

Table 1. Trial details for early sown faba beans at Hart 2015-2017, and Warnertown, Wudinna and Tooligie 2020.

Year & Site	Time of Sowing		
	1	**2**	**3**
2015 – Hart	14th April	6th May	27th May
2016 – Hart	14th April	7th May	26th May
2017 – Hart	18th April	15th May	13th June
2020 - Warnertown	31st March	5th May	
2020 – Wudinna	31st March	7th May	
2020 – Tooligie	2nd April	6th May	

Table 2. Season annual and growing season rainfall (GSR) recorded at Hart 2015-2017, and Warnertown, Wudinna, and Tooligie 2020, compared to long-term averages.

Year & Site	Rainfall Zone	Season GSR	Long-term GSR	Season Annual Rainfall	Long-term Annual Rainfall
2015 – Hart	Med	230 mm	297 mm	353 mm	406 mm
2016 – Hart		356 mm		485 mm	
2017 – Hart		191 mm		331 mm	
2020 - Warnertown	Low	344 mm	265 mm	489 mm	372 mm
2020 – Wudinna	Low	178 mm	236 mm	231 mm	326 mm
2020 – Tooligie	Med	252 mm	293 mm	318 mm	388 mm

Results

Trials in 2015-2017 at Hart evaluated the performance of several commercial varieties and developing germplasm, most of which are now commercially available varieties also, across three times of sowing in three contrasting seasons (Figure 1). Results from 2015 indicated that there was a significantly positive grain yield response to sowing early in mid-April, compared to sowing in early-May, with a further decrease in grain yield in the later sowing towards late-May. These results reflect the outcome of a season that was considered below average with a very hot, dry, and early finish, favouring early sowing as most of the reproductive development occurred prior to the exposure of high temperatures and low stored soil moisture.

Compared to a low growing season rainfall (GSR [April to October]) of 230 mm (average is 297 mm) in 2015, the following season in 2016 was well above average, recording 356 mm (Table 2). Due to the considerable increase in available moisture, most of the varieties recorded higher amounts of biomass from the earliest sowing date, while the other two sowing dates recorded lower and more variable biomass between varieties (data not shown). Because of the increased levels of biomass produced, coupled with the increased moisture and canopy humidity during the season, conditions were more conducive to the infection of diseases, where small outbreaks of ascochyta blight were observed in commercial varieties Farah, PBA Rana and PBA Zahra. From the grain yield data in

2016, it was found there was no sowing date by variety interaction on grain yield at Hart (Figure 1). However, the effect of sowing date on grain yield was significant despite the very high yields achieved at all sowing dates, with yield advantages being exhibited through the earlier sowing dates.

Seasonal conditions in 2017 changed significantly compared to 2016, with a GSR of 191 mm and decline in annual rainfall (Table 2). Early flower production was exposed to frost events during the first couple weeks of July, with minor levels of flower drop occurring during this critical growth period. Severe hot and dry conditions were also experienced at the beginning of October, which coincided with pod fill in the first two times of sowing, and full flowering in the mid-June sowing time. A grain yield response to ToS was observed in some varieties, with PBA Marne recording the highest grain yield when sown within the mid-April sowing time (Figure 1). With a sowing delay to mid-May, PBA Marne and PBA Zahra still yielded higher than other commercial varieties, including Farah and Nura, however, grain yield was reduced when compared to sowing in Mid-April. Sowing in Mid-June recorded the lowest yield response with most varieties yielding similarly. However, PBA Marne and PBA Zahra still yielded significantly higher than other entries, with the exception for PBA Samira, while the remaining three varieties yielded very similarly.

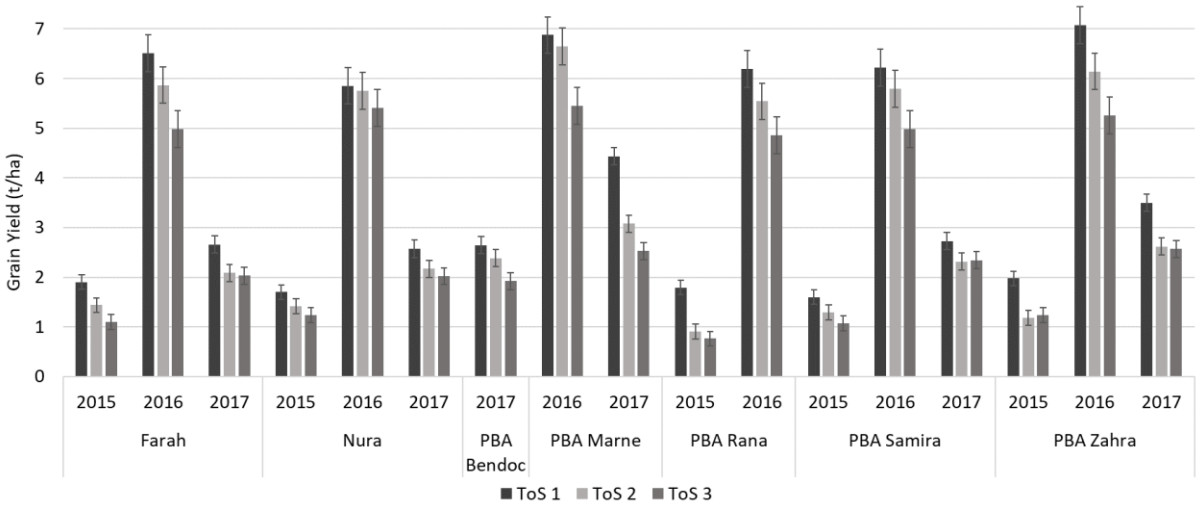

Figure 1. Faba bean variety grain yield response (t/ha) to ToS at Hart Field-Site, 2015-2017. Error bars represent standard error of the mean.

A comparable analysis can be made between a selection of varieties (PBA Bendoc, PBA Marne and PBA Samira) that were included in both the multi-year ToS trials at Hart and multi-site ToS trials located at Tooligie, Warnertown and Wudinna, 2020 (Figure 2). The growing season at each location was varied in 2020. Tooligie recorded a GSR of 252 mm (average is 293 mm) (Table 2). Conditions at Wudinna were also below average with a GSR of 178 mm (average is 236 mm). However, the season at Warnertown in 2020 was well above average with a GSR of 344 mm (average is 265 mm).

All varieties had a positive grain yield response from early sowing, although not all varietal responses were significant (Figure 2). PBA Marne consistently yielded higher than PBA Bendoc and PBA Samira when sown early in every location, regardless of the decile rainfall received during 2020. PBA Bendoc still yielded significantly higher when sown early, with an increased response of over 1.0 t/ha seen at Tooligie, compared to smaller responses at Warnertown and Wudinna. PBA Samira still had a positive response to early sowing, although not as significant as the other two varieties and appears to provide more stable grain production across varying sowing dates, thereby providing adaptability to a wider sowing window. From the delay in sowing, the difference in grain yield at every location did not differ significantly, regardless of the variety sown or the decile rainfall received at that location.

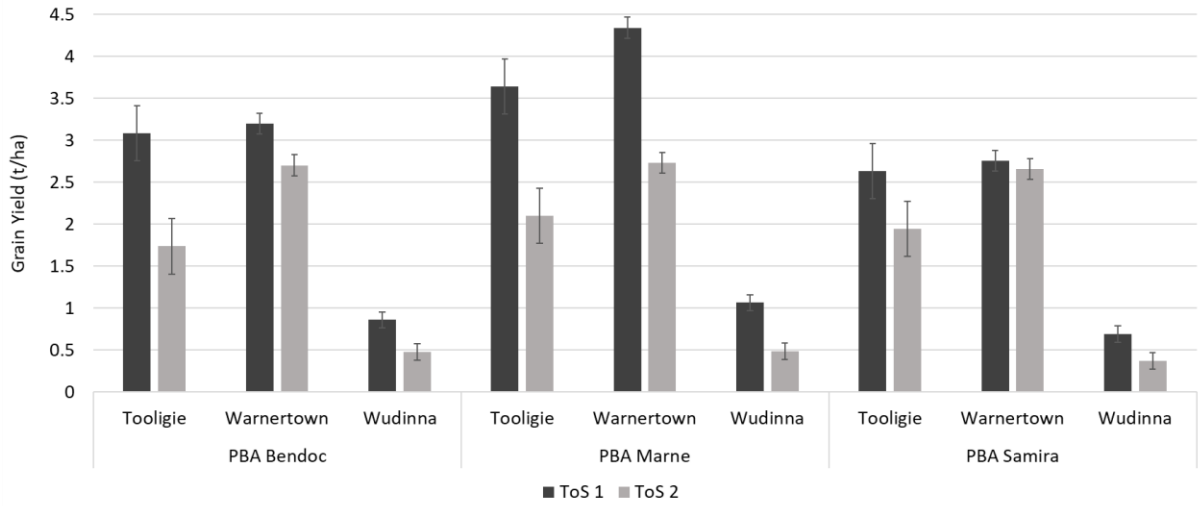

Figure 2. Faba bean variety grain yield response (t/ha) to ToS at Tooligie, Warnertown and Wudinna, 2020. Error bars represent standard error of the mean.

Conclusion

This data demonstrates that breeders have developed faba bean germplasm with an adaptability to early sowing opportunities, that are able to consistently perform well when sown during the first two weeks of April in low to medium rainfall environments in SA, regardless of above or below average seasonal rainfall. In contrasting seasonal conditions, early sown faba beans in these environments have consistently delivered increases in grain yield, with an emphasis on earlier flowering varieties such as PBA Marne, that have proven to be the most responsive to these situations, while PBA Samira has exhibited increased levels of yield and flowering stability across a wide sowing window. Further research is required to determine an optimal sowing window when an early sowing opportunity presents itself in low to medium rainfall environments. Previous research has established the negative impact of delayed sowing on grain yield and crop performance of pulse crops, however, the implications of pushing the limit on what would be considered unreasonably early sowing, if the opportunity presents itself through sufficient available moisture or an early break in the season, has not yet been established. This research would then give an indication of when management decisions, such as time of sowing, can deliver an increased return to growers, while taking a custodial approach to other variables within a production system, such as weed, pest and disease control, and the logistics of effective farming practices.

Acknowledgements

This research was funded by GRDC project DAV00150.

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