A systems approach to break crop selection in low rainfall environments

Sarah Day[1], Helena Oakey[2], Penny Roberts[1]

[1] South Australian Research and Development Institute, 70 Farrell Flat Road, Clare, SA, 5453, Email: sarah.day@sa.gov.au
[2] University of Adelaide, Waite Building, Waite Road, Urrbrae, SA, 5673

Abstract
Current farming systems in the low rainfall zone of southern Australia are dominated by cereal production. Although the benefits of break crops to the farming system are well known to growers, there is a lack of information available about choosing the break crop best suited to low rainfall farming systems. To address this knowledge gap, trials have been established to assess the performance of different varieties of a range of break crop species at key locations in the southern low rainfall zone. Performance of break crop species varied across environments, but there were strong correlations identified between some environments in a multi-environment trial analysis. Nuseed Diamond canola, PBA Samira faba bean, Volga vetch and PBA Bateman lupin consistently performed well compared to other varieties of their respective crop species. Genesis™090 chickpea, PBA Striker chickpea, PBA Bolt lentil, PBA Hallmark XT lentil, PBA Butler field pea, PBA Twilight field pea, and PBA Wharton field pea were the top performing varieties for their respective crop species, depending on the environment. Each break crop species has its own unique fit, and available agronomic and paddock information needs to be considered when selecting a break crop option for individual farming systems.

Key Words
Farming system, pulse, legume, rotation

Introduction
Current farming systems in the low rainfall zone (<325 mm) of southern Australia are dominated by cereal production. There is increasing concern about grass weed and soil-borne disease pressure, as well as diminishing soil fertility (particularly nitrogen), and poor water use efficiency as a result of continuously cropping cereals (Angus et al. 2015; McBeath et al. 2015; Seymour et al. 2012). Break crops have a key role to play in addressing these issues, as well as diversifying crop production and economic risk, and maintaining long-term sustainability of the system. The success of a break crop is critical for gaining the most benefit out of the break phase for the subsequent crops. The use of a break crop in a cereal dominant cropping system consistently results in at least 1 t/ha of additional yield in the subsequent crop in low rainfall environments (McBeath et al. 2015) and can improve profitability of the farming system by up to $100/ha per year (Moodie and Wilhelm 2016). However, there remains a lack of information available to growers about choosing the break crop best suited to their situation, as break crop development to date has largely occurred in medium and high rainfall zones. The aim of this research is to identify the best break crop species and varieties for different climate, soil type and biotic stress situations within major cropping regions of the southern low rainfall zone.

Methods
To address the project aim, break crop species-by-variety trials were initially undertaken in 2017 at four key locations across the southern low rainfall zone, were expanded to new locations in 2018, and will be repeated again in 2019. The trials include three to six varieties (to represent potential options for the low rainfall zone) of canola, chickpea, faba bean, field pea, lupin, lentil, and vetch. Varieties were selected following consultation with breeders, researchers, and advisors. Varietal options include herbicide-tolerant varieties and those with a potential alternative end-use to grain, such as grazing or hay. Trial measurements include site soil characteristics, soil moisture, seasonal temperature and rainfall, grain yield, biomass yield, and gross margin. Trials were sown using an experimental plot seeder. Biomass yield was measured at late flowering to early pod development growth stage to identify potential use as a hay, forage or manure crop. Trials were harvested at crop maturity using an experimental plot harvester. Gross margin was calculated using the PIRSA Rural Solutions ‘Farm Gross Margin and Enterprise Planning Guide’, inputs used in the trial and yields were used to calculate the gross margin. Plot arrangement was a split plot design with three replicates, with break crop species randomly assigned to the whole plot and variety to the sub plot. The use of this design ensures each break crop species receives appropriate agronomic management. A multi-environment trial analysis using a factor analytic model (Smith, Cullis and Thomson 2001), with adjustment for design

factors and spatial variation, was conducted for biomass and grain yields. Models were fitted in ASReml-R (Butler et al. 2009) in the statistical software platform R. Trial sites analysed were Mildura, (Mallee, Victoria), Pinnaroo (Mallee, South Australia), Willowie (Upper North, South Australia), Minnipa (Upper Eyre Peninsula, South Australia) and Warnertown (Upper North, South Australia).

Results and Discussion

The multi-environment trial analysis identified strong correlations between Pinnaroo 2018 and Mildura 2018 (0.97), and Willowie 2018 and Minnipa 2018 (0.9) for biomass yield (Figure 1). There were also strong correlations between Mildura 2018 and Warnertown 2018 (0.85) and Willowie 2018 and Mildura 2018 (0.80) for biomass (Figure 2). There were weak or negative correlations for all other environments included in the analysis, and high variation is often observed between these environments. Lupin biomass production was low compared to other break crop species at Mildura and Pinnaroo, 2018 (Figure 1). The soils at these sites are strongly alkaline (pH_{water} 8.4-9.6) and lupin prefers a low to neutral pH soil. ATR Stingray and ATR Bonito canola, PBA Monarch chickpea, PBA Bendoc faba bean, and PBA Jumbo2 and PBA Blitz lentil have been relatively poor performing varieties for their respective crop species across the low rainfall environments for biomass production. Open pollinated ATR Stingray has been a poor performing canola variety across all environments, while hybrid variety Nuseed Diamond has provided relatively high biomass production. Pioneer 44Y90 (CL) also had higher biomass production at the Mallee sites, while Hyola 559TT had higher biomass production in the Upper North and Upper Eyre Peninsula, compared to other canola varieties (Figure 2). Both semi-leafless and conventional type field pea varieties were included in the trial to look at alternative end-use options to grain. However, conventional type field pea has not offered improved biomass production over semi-leafless type. Additionally, conventional type field pea has poor lodging resistance, and therefore semi-leafless varieties may be a more suitable option, regardless of end-use. PBA Butler and PBA Coogee produced high levels of biomass in the Mallee, while PBA Twilight and PBA Wharton performed better in the Upper North and Upper Eyre Peninsula.

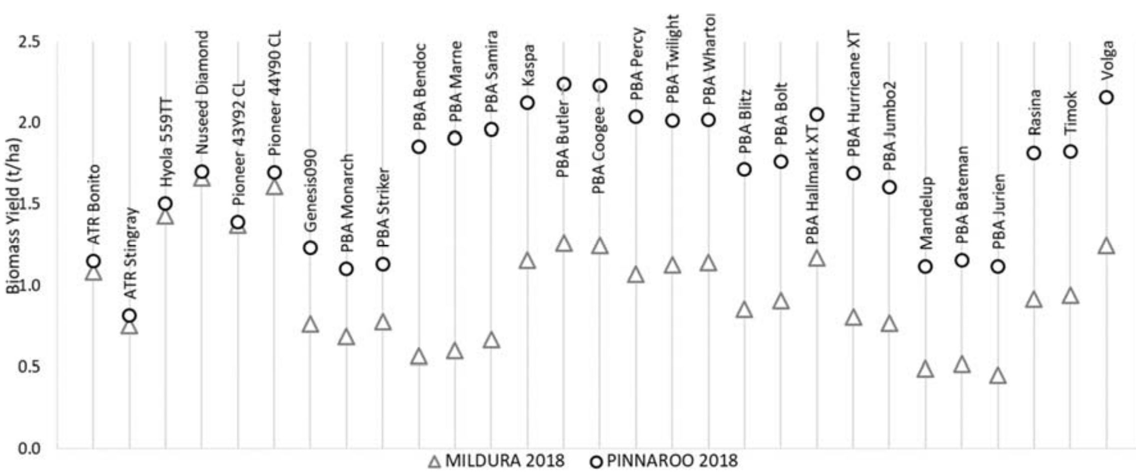

Figure 1. Relationship (0.97) between Mildura 2018 and Pinnaroo 2018 for biomass yield.

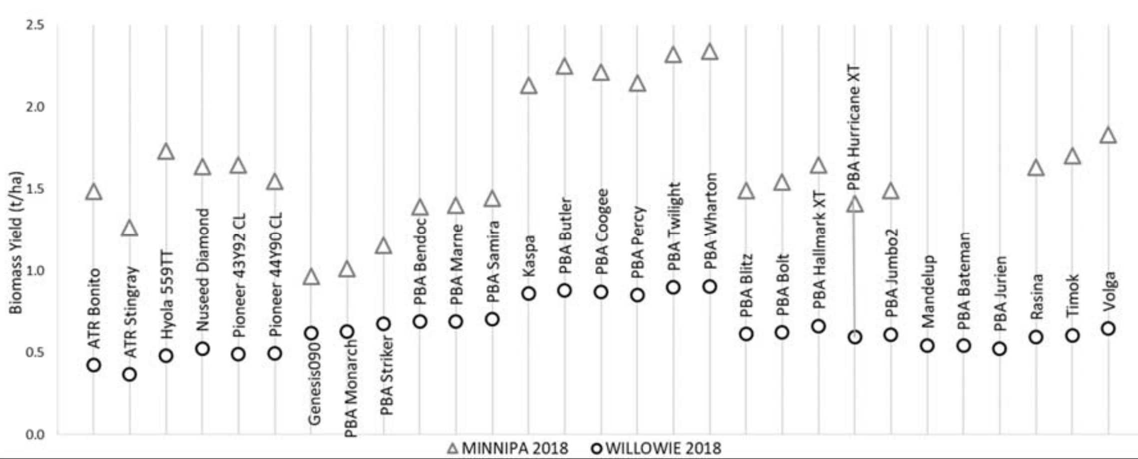

Figure 2. Relationship (0.90) between Minnipa 2018 and Willowie 2018 for biomass yield.

There were strong correlations between Pinnaroo 2018 and Mildura 2018 (0.98), Pinnaroo 2018 and Minnipa 2018 (0.92) and Minnipa 2018 and Mildura 2018 (0.89) for grain yield (Figure 3). There was also a strong correlation between Warnertown 2018 and Minnipa 2017 (0.85) for grain yield (Figure 4). Willowie 2017, had relatively weak correlations to other environments (0.27-0.65), in particular the Mallee environments (0.27-0.4). Field pea and vetch had low grain yield at Pinnaroo in 2018 due to multiple spring frost events during reproductive growth stages (Figure 3). Lentil and vetch yields were low at Minnipa in 2017 due to early herbicide damage (Figure 4). ATR Stingray canola and PBA Monarch chickpea had low grain yield across all environments compared to other varieties of their respective crop species. PBA Blitz lentil and PBA Bendoc faba bean had low grain yields at Minnipa and Warnertown. Nuseed Diamond is a fast growing and early maturing hybrid canola variety and produced higher grain yield than other canola varieties across all environments tested. Desi chickpea PBA Striker had higher grain yield across most environments compared to the kabuli varieties. Desi chickpea is generally earlier maturing than kabuli chickpea and may be better suited to short seasons and low rainfall environments. PBA Samira faba bean has performed well for both biomass and grain production across all environments, and generally similar to, or slightly better than, PBA Marne (low rainfall or short season adapted variety). In general, PBA Butler, PBA Twilight and PBA Wharton have been the higher yielding varieties for field pea in these low rainfall environments. Early maturing vetch variety Volga has high grain yield and biomass potential, and has proved to be the top performing of the vetch varieties assessed across the low rainfall environments. PBA Bolt and PBA Hallmark XT lentil varieties have performed well across all environments for both biomass and grain production. PBA Bolt offers early to mid-flowering and maturity, lodging resistance, improved boron and salt tolerance, and high grain yield in drought years and dry areas. It is therefore well adapted to low rainfall environments. PBA Hallmark XT offers improved herbicide tolerance to conventional lentil varieties, and would be well suited to areas or seasons where Group B herbicide residues are an issue.

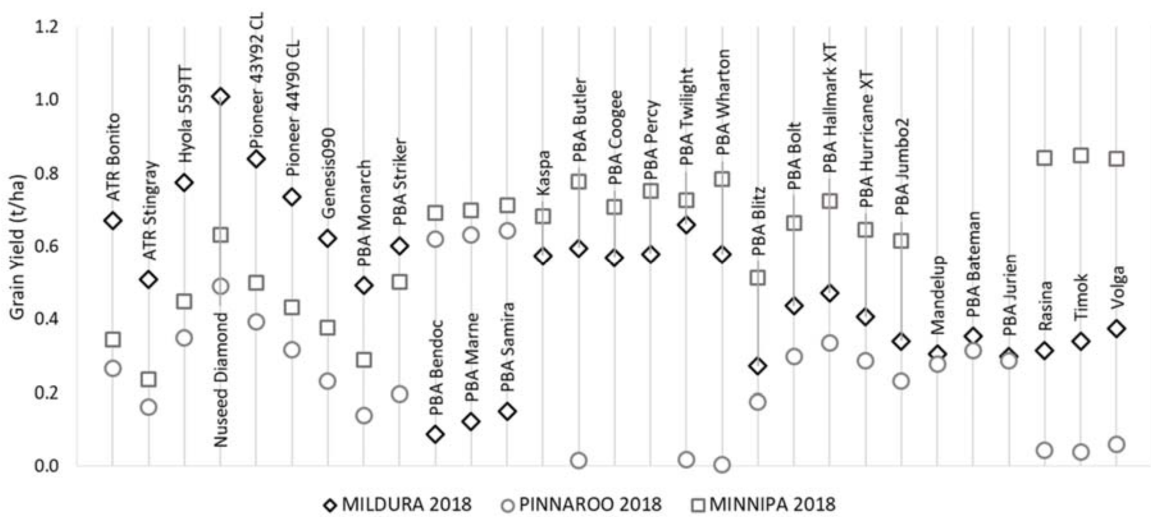

Figure 3. Relationship (0.89-0.98) between Mildura 2018 Pinnaroo 2018 and Minnipa 2018 for grain yield.

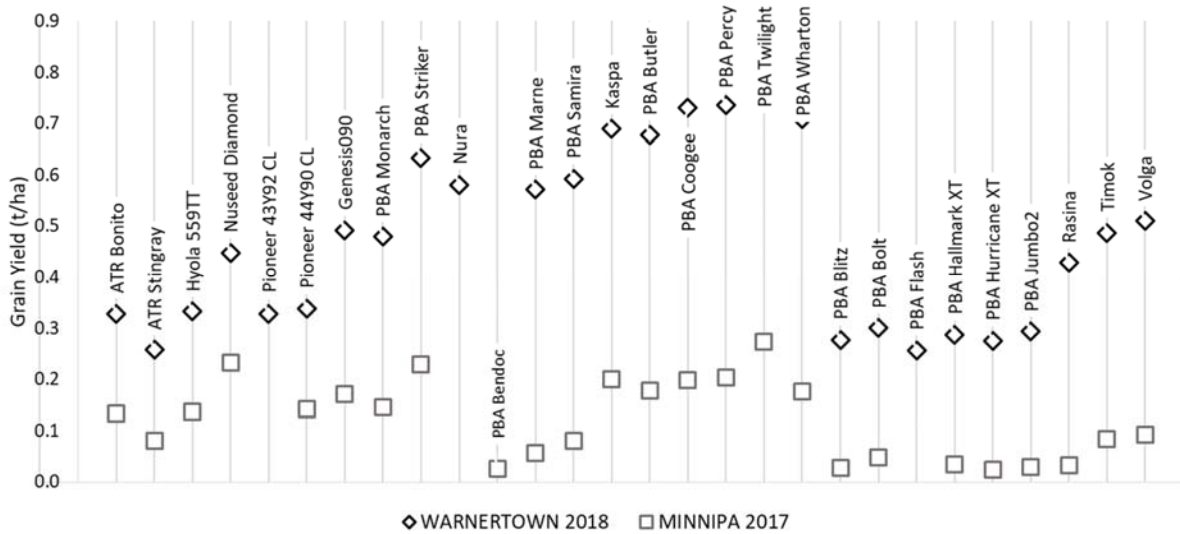

Figure 4. Relationship (0.92) between Warnertown 2018 and Minnipa 2017 for grain yield.

Conclusion

The decision to grow a break crop is generally done with a whole systems approach, as break crops can be utilised to address the issues and constraints that arise from continuous cropping of cereals. Therefore, the decision of which break crop to grow is made depending on the reason for growing a break crop, crop end-use, financial risk, paddock selection and soil type. Field pea is least suited to frost prone areas, and is a high risk for grain production where spring frosts occur. However, field pea has multiple alternative end-uses to grain, and with high biomass potential can be utilised as a hay, forage, silage or manure crop when frosted or drought affected, to salvage a financial return. Vetch is also a versatile crop, having multiple potential end-uses, and is a good fit in a mixed farming system. Lupin is well suited to sandy or acid soils, and has potential to be utilised as a green/brown manure crop. Canola, lentil and faba bean can provide herbicide tolerant crop options where in-crop weeds or herbicide residues are an issue. Canola can also have a good fit where cereal root diseases are limiting production (Kirkegaard et al. 2008). However, canola required adequate soil moisture at sowing for successful germination. Lentil is more sensitive to soil constraints than other break crop options and plant height is often low, leading to poor harvestability. Faba bean has performed relatively well across the low rainfall environments, particularly where spring frost events have badly affected other crop species, as faba bean tolerates reproductive frost events better than other pulse crops. Our work has shown each break crop species has its own unique fit in the system, and all available agronomic and paddock information needs to be taken into consideration when selecting a break crop to fit into each individual farming system.

References

Angus J, Kirkegaard J, Hunt J, Ryan M, Ohlander L, Peoples M (2015). Break crops and rotations for wheat. Crop and Pasture Science 66, 523-552.

Butler D, Cullis B, Gilmour A and Gogel B (2009). ASReml-R Reference Manual. Technical report, Queensland Department of Primary Industries, Toowoomba, Australia.

Kirkegaard J, Christen O, Krupinsky J, Layzell D (2008). Break crop benefits in temperate wheat production. Field Crops Research 107, 185-195.

McBeath T, Gupta V, Llewellyn R, Davoren C, Whitbread, A (2015). Break crop effects on wheat production across soils and seasons in semi-arid environment. Crop and Pasture Science 66, 566-579.

Moodie M and Wilhelm N (2016). Profitable crop sequence in the low rainfall regions of south eastern Australia (DAS00119). A report of the key findings from five long term trial sites.

Seymour M, Kirkegaard J, Peoples M, White P, French R (2012). Break-crop benefits to wheat in Western Australia – insights from over three decades of research. Crop and Pasture Science 63, 1-16.

Smith A, Cullis B and Thompson (2001). Analyzing variety by environment data using multiplicative mixed models and adjustment for spatial field trends. Biometrics 57, 1138-1147.