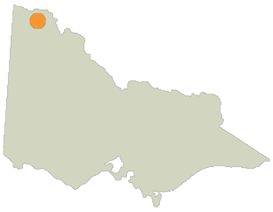
Two year breaks profitably reduce agronomic constraints in the Northern Victorian Mallee

Michael Moodie[1], Nigel Wilhelm[2], Roger Lawes[3], Peter Telfer[2], Todd McDonald[1]
[1]MSF Mildura; [2]SARDI Waite campus Adelaide, [3]CSIRO Perth



Why was the trial/project undertaken?

The Low Rainfall Crop Sequencing project commenced in 2011. At that point in time, crop sequences in the low rainfall region were dominated by intensive continuous cereal cropping and break crops occupied less than 5 percent of the landscape. These intensive cereal cropping sequences were declining in productivity with the emergence of agronomic constraints such as grass weeds, low soil nitrogen and crop diseases. The aim of this project was to test if including one and two-year break phases in low rainfall crop sequences could remove the agronomic constraints and increase the production of subsequent cereal crops. We also explored whether break crops could improve the profitability of the long term crop sequence when compared to maintaining continuous cereal.

How was the trial/project done?

The Mildura trial was located in the Millewa region of the Victorian Mallee. In 2011, nine different break options were established along with continuous wheat. In 2012, a second break phase was implemented (2-year break) or the rotation was returned to wheat (1-year break). In 2013, all rotations were returned to either conventional wheat (var. Shield) or Clearfield wheat (var. Grenade). In 2014, all plots were again sown to wheat (var. Grenade).

Throughout the trial, agronomic management was varied for each individual rotation to help maximise the profitability of that rotation and to respond to particular issues in each option. For example nitrogen inputs, varieties, sowing dates or herbicide applications were varied depending on the level and type of agronomic constraints in each rotation.

Key Messages

- Including 1 and 2-year break phases in the low rainfall Mallee can significantly increase the productivity of subsequent wheat crops.
- Brome grass population in a long term cereal paddock near Mildura was the most significant driver of the break benefits in a crop sequencing trial.
- Including a two-year break phase in the rotation was up to $90/ha/year more profitable than maintaining continuous wheat over the four year period of the trial.

Background

The Low Rainfall Crop Sequencing project commenced in 2011 with field trials at 5 sites (Minnipa (SA), Appila (SA), Mildura (Vic), Chinkapook (Vic) and Condobolin (NSW)) across the low rainfall zone of south eastern Australia. At that point in time, crop sequences in the low rainfall region were dominated by intensive cereal cropping and break crops occupied less than 5 percent of the landscape. Moreover these intensive cereal cropping sequences were declining in productivity due to agronomic constraints such as grass weeds, declining soil nitrogen fertility and crop diseases.

The aim of this project was to test if including one or two-year break phases in low rainfall crop sequences could successfully address agronomic constraints to increase the productivity of subsequent cereal crops and improve the profitability of the long term crop sequence when compared to maintaining continuous cereal. In this article we report on the yields and break crop effects observed in 20 different crop sequences and the profitability of the rotations over four seasons of the project (2011-2014) at the Mildura trial site.

About the trial

The Mildura trial was located in the Millewa region of the Victorian Mallee. In 2011, nine different break options were established along with continuous wheat. In 2012, a second break phase was implemented (2-year break) or the rotation was returned to wheat (1-year break). In 2013, all rotations were returned to either conventional wheat (var. Shield) or Clearfield wheat (var. Grenade). In 2014, all plots were again sown to wheat (var. Grenade).

Long term average rainfall at Mildura is 290 mm with approximately two thirds falling in the growing season (April to October) (Table 1). In 2011, record rainfall (444 mm) fell between January and March, filling the soil moisture profile prior to sowing. However only a further 108 mm of rainfall was received in the growing season. Very low growing season rainfall (92 mm) was also received in 2012 which also had a very late 'season break' with significant opening rains not received until July. Average growing season rainfall was received in the 2013 and 2014.

Throughout the trial, agronomic management was varied for each individual rotation to help maximise the profitability of that rotation and to correct the agronomic constraints that emerged for that rotation. For example nitrogen inputs, varieties, sowing dates or herbicide applications were varied depending on the level and type of agronomic constraints in each rotation.

Gross Margins were calculated for each treatment in each season using the 'Farm Gross Margin and Enterprise Planning Guide' (Rural Solutions 2011, 2012, 2013, 2014 and 2015). Costs were calculated using the actual inputs used in the trial and the values provided in the corresponding gross margin guide. The commodity price stated for January in the year after yield was measured was used to calculate the income (e.g. 2011 yield x January 2012 price). Treatment grain yields were used for calculating income and 85% of dry matter yield was used for calculating hay yield. For pastures, income was calculated using the dry sheep equivalent (DSE) cereal zone gross margin for a prime lamb enterprise and a nominal stocking rate of 2 DSE per winter grazed hectare, irrespective of pasture production.

Table 2. *Monthly rainfall (mm) at Mildura Airport for the duration of the trial. Mean is the long term average rainfall.*

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	22	23	21	18	25	22	26	26	27	29	26	26	290
2011	129	193	122	13	14	11	15	21	7	28	43	62	657
2012	13	37	64	4	3	8	41	17	13	6	5	4	215
2013	1	15	11	6	29	36	15	10	19	14	2	58	216
2014	1	67	29	58	23	6	13	18	19	1	13	10	257

Results

Treatment Yields

Grain yields achieved from each treatment over the four years of the trial are presented in Table 2. Crop yields were slightly above district expectations in 2011 with field peas the standout crop at the site. The poorest crop yields were achieved in 2012 due to very low growing season rainfall and a late break. In the 2013 and 2014 seasons when the whole site was sown to wheat, the yields of the continuous wheat treatment were in line with district expectations, however large break effects were observed in many of the treatments where break phases were previously implemented.

Dry matter (DM) yield was also measured for non-grain crops. In 2011, DM production was high across all crops with Oaten Hay yielding 4.8 t/ha, vetch producing 2.7 t/ha and medic producing 3.2 t/ha. A late break and low in-crop rainfall in 2012 constrained the dry matter production of vetch (0.99 t/ha). However, volunteer medic pasture which was able to germinate after 64 mm of rainfall in march (Table 2) accumulated very high dry matter yields (7.1 t/ha) despite the poor growing season rainfall.

Table 2. *Grain yields for grain crops over four years (2011-2014) at the Mallee Crop Sequencing Trial*

2011 Crop	Yield t/ha	[b]2012 Crop	Yield t/ha	[b]2013 Crop	Yield t/ha	[b]2014 Crop	Yield t/ha
Canola (TT)	0.93	Chickpea	0.30	Wheat	2.57	[lx]Wheat CL	1.41
Canola (TT)	0.62	Field peas	1.17	Wheat	2.44	[lx]Wheat CL	1.43
Canola (TT)	0.66	Vetch (Brown Manure)	NA	Wheat	2.54	[lx]Wheat CL	1.54
Chickpea	0.83	Canola (TT)	0.39	Wheat	2.31	[lx]Wheat CL	1.61
Chemical Fallow	NA	Canola (Clearfield)	0.27	Wheat	2.27	[lx]Wheat CL	1.52
Chemical Fallow	NA	Chemical Fallow	NA	Wheat	2.42	[lx]Wheat CL	1.20
Chemical Fallow	NA	Field peas	1.24	Wheat	2.50	[lx]Wheat CL	1.60
Medic (high seed rate)	NA	Medic (volunteer)	NA	Wheat	1.96	[lx]Wheat CL	1.43
Medic (low seed rate)	NA	Medic (volunteer)	NA	Wheat	2.19	[lx]Wheat CL	1.54
Field pea	1.35	Canola (TT)	0.39	Wheat	2.32	[lx]Wheat CL	1.33
Field pea	1.93	Vetch (Brown Manure)	NA	Wheat	2.67	[lx]Wheat CL	1.57
Vetch (Brown Manure)	NA	Canola (TT)	0.25	Wheat	2.58	[lx]Wheat CL	1.84
Vetch (Brown Manure)	NA	Field pea	0.77	Wheat	2.60	[lx]Wheat CL	1.83
Barley	2.2	Wheat	0.76	[lx]Wheat CL	1.04	[lx]Wheat CL	1.78
Canola (Clearfield)	0.59	[lx]Wheat CL	1.05	Wheat CL	1.44	[lx]Wheat CL	1.17
Canola/Field pea mix	1.17	Wheat	0.87	[lx]Wheat CL	1.00	[lx]Wheat CL	1.69
Oaten hay	NA	Wheat	0.82	[lx]Wheat CL	1.22	[lx]Wheat CL	1.69
Field peas	2.05	Wheat	1.26	[lx]Wheat CL	1.12	[lx]Wheat CL	1.69
Chemical Fallow	NA	Wheat	1.26	[lx]Wheat CL	1.30	[lx]Wheat CL	1.65
Wheat	1.47	[lx]Wheat CL	0.93	Wheat CL	1.42	[lx]Wheat CL	1.31
LSD (Grain Yield Only)	**0.44**		**0.25**		**0.20**		**0.20**

[b] Wheat CL is Clearfield wheat

[lx] Intervix applied to the Clearfield wheat

Break effects

Including break phases in the rotation increased the productivity of subsequent cereal crops relative to maintaining continuous wheat. A one-year break phase of field pea or fallow in 2011 led to an increase of 0.3 t/ha and one year of canola resulted in a 0.1 t/ha yield benefit in the 2012 wheat crop. In 2013, the benefit of having a two-year beak prior to 2013 was 0.5-1.25 t/ha. However the benefit of the 1-year break crop options from 2011 only lasted a single season. Two-year break crop benefits were also observed in 2014 with selected rotations having up to a 0.4 t/ha greater yield than continuous wheat.

The importance of brome grass, soil nitrogen, rhizoctonia and soil water to the yield difference between break options and continuous wheat was analysed for wheat yields in 2013 and 2014 (Figure 1).

2013 was the first year following a two-year break and second year following a one-year break. Averaged across all positive break effects, 39 percent of these yield increases were due to less brome grass, 38 percent to more nitrogen, 19 percent to less rhizoctonia and four percent to more water. Where negative break effects were observed, 77 percent of the difference was due to increased brome grass, 15 percent to increased rhizoctonia, six percent to less water and two percent to less nitrogen.

Brome grass was the dominant driver of positive break effects in 2014 accounting for an average of 80 percent of the differences in wheat yield. Higher soil nitrogen levels accounted for a further 18 percent of the positive break effect. Where continuous wheat in 2014 out yielded wheat following a break option, nitrogen accounted for 58 percent and brome grass 37 percent of the difference. Rhizoctonia and soil water accounted for very little of the yield differences observed in the trial in 2014.

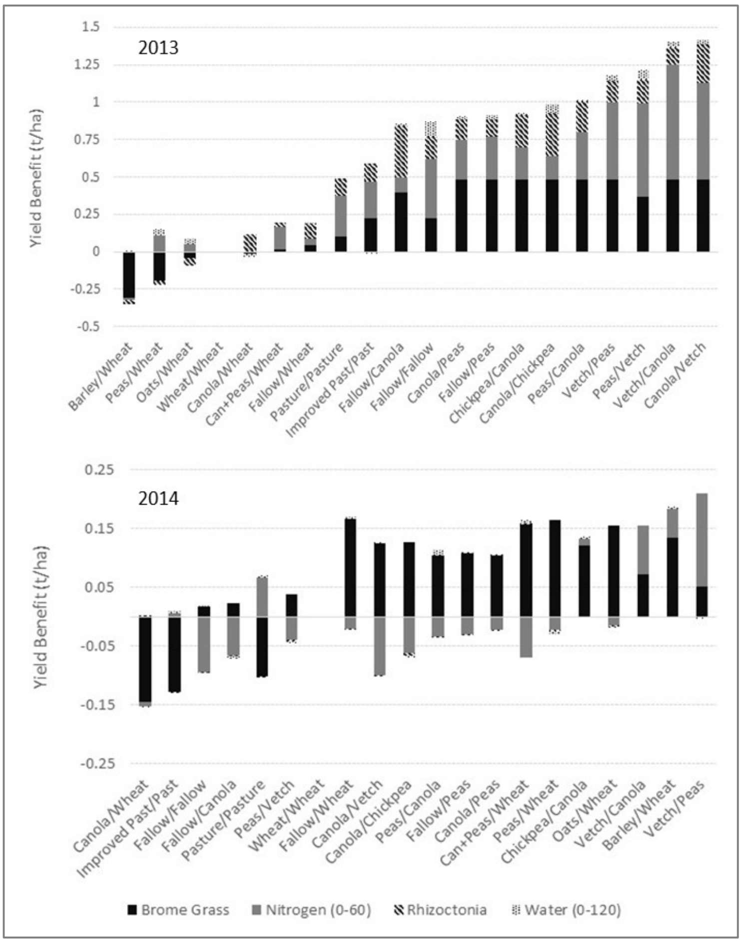


Figure 1. *Contribution of Brome grass (in-crop), mineral nitrogen (pre-sowing mineral 0-60 cm), rhizoctonia (pre-sowing inoculum) and soil water (pre-sowing 0-120 cm) to break effect (difference between treatment and continuous cereal yield in the Mildura trial in 2013 and 2014). A positive effect means that the difference in the level of the agronomic constraint increased the yield of the break relative to continuous wheat and a negative effect means the level of the agronomic constraint resulted in less yield in the break option than in the control.*

Long term profit

Gross margins were calculated for all treatments in each year and then accumulated for each sequence for the duration of the trial (Figure 2). Over four seasons, 15 of the 19 rotations were more profitable than maintaining continuous wheat. On average, the top five most profitable rotations were $360/ha or $90/ha per year more profitable than continuous wheat. Furthermore, four of the top five most profitable rotations included two years of a break. Key characteristics of the most profitable rotations that included a two-year break were the inclusion of at least one profitable break crop in the sequence and the alleviation of agronomic constraints resulting in increased profitability in the wheat crops following the break phase.

Of the rotations that were less profitable than wheat, three of the four included at least one fallow phase. The other rotation was a two-year pasture, which had a high brome grass population because the only weed control tactic was to spray top. However, the absolute difference in gross margin between these treatments and the continuous wheat treatment was small (on average less than $40/ha or $10/ha/year).

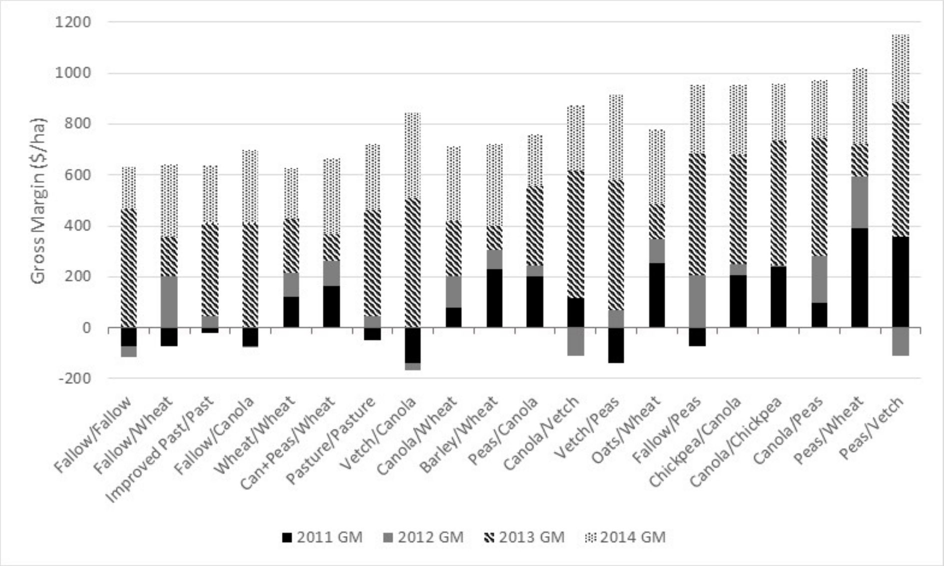


***Figure 2.** Seasonal gross margins (2011-2014) for each treatment in the low rainfall crop sequencing trial site at Mildura.*

Implications for commercial practice

This project has demonstrated that diversified cropping sequences have an important role to play in low rainfall Mallee farming systems. Including 1- and 2-year break phases were shown to significantly increase the productivity of subsequent wheat crops. In this trial, the greatest break crop benefits immediately following the break phase were due to reduced weed number and improved nitrogen status. Reduced rhizoctonia inoculum and additional stored soil water were important in select rotations, although the benefits were much smaller than for addressing grass weed and nitrogen constraints. In the second wheat crop, grass weed numbers were the major driver of the yield differences between treatments.

This project showed that including a two-year break phase in the rotation was often more profitable than maintaining continuous wheat. These profitability benefits were significant, with the best treatments generating $90/ha/year more profit than the continuous wheat treatment. A key driver of increased profit was to have at least one profitable break crop in the rotation. Therefore, future research should focus on finding low cost, reliable and profitable break phase options for farmers in low rainfall regions such as the Mallee.

Links and references

Rural Solutions SA (2011, 2012, 2013, 2014, 2015). Farm Gross Margin and Enterprise Planning Guide (Years 2011, 2012, 2013, 2014, 2015). http://solutions.pir.sa.gov.au/news/news/newspaper_items/2014/farm_gross_margins_and_enterprise_planning_guide_2015

Acknowledgements

This trial is a collaboration between MSF and SARDI with funding from the GRDC.