17. Crop Sequencing Project: Regional specific examples from recent local research

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Funding Body: GRDC Project Code: CSP00146 Project Duration 2010-2015

KEY OUTCOMES

- Break crops can be just as profitable as wheat crops
- Antas sub-clover (for hay production) as the break crop was the most profitable option
- Beans were the most effective at fixing nitrogen, averaging 13 kgN/tDM produced

Introduction

This report summarises the findings from a five year project conducted at Lochaber. The report is an extract from the full document which covers sites across the high and medium rainfall zone and has been compiled as part of the project. This document will be available on line shortly.

The project aimed to answer three key questions:

1. Can a break crop be as profitable as a cereal?
2. Are crop sequences including break crops more profitable than continuous wheat? and
3. What effects do break crops have on soil nitrogen availability?

The report is split into three sections below; each addressing these questions.

Figure 1. *Photo of site with sequences set up in initial year of the phase.*

Summary

A three phased experiment was run in Naracoorte SA, with a series of break options and cereal treatments sown in Year 1 of each phase. The first phase (Experiment 1), established in 2011 and the second phase (Experiment 2), established in 2013 are shown here to illustrate the key learnings from the trials. Sowing a break crop into bean stubble (Experiment 3), established in 2012, (data not shown) reduced the impact of the experimental break crop as the benefit from the bean stubble was evident in subsequent rotations.

In Year 2 for each of the trials, break crop and cereal treatments were all sown to wheat. The first phase (Experiment 1) had two times of sowing and four different nitrogen rates and the second phase (Experiment 2) had one time of sowing and eight different nitrogen rates. In the third and final year of each of the phases barley was sown and managed the same across all plots.

The reason for the repeatability of the trial over three years was to capture variations in seasonal conditions. It must be noted that 2014 and 2015 seasons experienced below average rainfall from July to October. August and September 2014 and September 2015 were in the 10th percentile for rainfall and October 2015 was the driest on record.

Table 1. *Monthly rainfall (mm), long-term rainfall (LTR) (mm) and growing season rainfall (GSR) March to October (mm), for 2011-15 at the Lochaber trial site.*

(Naracoorte (View Bank) Station 26104 (36.85°S, 140.56°E, 42 m elevation) accessed online from Australia Bureau of Meteorology (http://www.bom.gov.au)).

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual	GSR - March - October
2011	64.8	67.4	83.0	22.0	38.4	58.8	95.6	64.6	53.8	30.8	29.0	28.0	636.2	447.0
2012	4.2	1.6	27.4	18.2	36.8	94.2	66.0	80.8	33.6	26.0	11.8	17.4	418.0	383.0
2013	0.6	10.4	16.6	18.2	50.4	60.4	102.0	101.2	61.2	55.8	18.0	13.6	508.4	465.8
2014	26.2	0.8	14.0	38.4	38.0	84.0	68.8	21.0	16.4	11.0	20.0	10.8	349.4	291.6
2015	62.0	2.0	9.0	26.6	48.2	28.4	49.0	35.4	25.2	3.4	23.7	-	-	225.2
LTR	26.5	18.5	24.9	28.5	39.8	58.3	74.2	63.1	43.6	30.0	32.7	38.1	433.3	

Q1. Can a break crop be as profitable as a cereal?

- **Naracoorte Experiment 1**
- **Naracoorte Experiment 2**

This research project has shown that various break crops can be as profitable as wheat. In all three years of experiments sub clover (hay) returned a higher gross margin than wheat (grain) and in two of the three years this increase in financial return was significant (e.g. Table 2). Beans and winter sown peas also had significantly higher returns compared to wheat grain in two of the three years.

Safflower tended to have similar returns as the wheat grain treatment.

The canola treatment returns were variable over the three years. In Experiment 1, canola grain had a significantly higher return then wheat grain. In the other two years wheat grain had a higher (although not significant) return compared to canola grain. In Experiment 1, canola grain had a higher yield, 2.3 t/ha (Table 2), compared to Experiment 2, which was 1.7 t/ha (Table 3). A big difference between Experimental years was the commodity price for canola grain, ranging from $500/t (2011), $540/t (2012) and $490/t (2013). Therefore the variation in canola returns is driven by the volatility of the commodity price.

Over the life of the project the spring sown, barley and pea break crops were not as profitable as wheat.

Q1 - Naracoorte Experiment 1

The results from the first year (2011) of Experiment 1 (Table 2) show that there were many treatments that were more profitable than wheat in a single year. In fact, the only treatments that were less profitable than wheat were those that were spring sown instead of winter sown. Subclover was by far the most profitable treatment, with a gross margin three times that of the wheat treatments.

Table 2. *YEAR 1 2011 break crop yield/dry matter (t/ha) and Gross Margin ($/ha).*

Arranged in descending order of Gross Margin

Break Crop Sown 2011	YEAR 1 2011	YEAR 1 2011	YEAR 1 2011
	Yield t/ha	biomass t/ha	Gross Margin ($/ha)
Sub clover (hay)	-	7.6	1051
Canola (grain and graze)	2.2	1.1	690
Canola (grain)	2.3	-	678
Peas (winter sown)	3.3	-	635
Beans	2.8	-	528
Canola (hay)	-	8.4	343
Wheat (grain)	3.8	-	336
Wheat (grain and graze)	3.7	0.5	336
Safflower (spring sown)	1.4	-	307
Wheat (0.3 m rows)	3.4	-	301
Barley (spring sown)	3.0	-	198
Peas (spring sown)	1.6	-	86
P value	<0.001	-	<0.001
l.s.d (P<0.05)	0.7	-	145

Q1 - Naracoorte Experiment 2

Table 3 highlights that in a different growing season (2013) (compared to 2011 in Experiment 1), there were again many treatments that were more profitable than wheat in a single year. In 2013, the trends in profitability were similar to that in 2011 (Table 2) except for the canola treatment. The canola treatment was less profitable than the wheat due to different seasonal conditions. The canola yields were lower and input costs were higher due to greater weed and insect pressure than in 2011. However, it remained more profitable than the spring sown options. These differences highlight the importance of multi-year comparisons to capture seasonal variability.

Table 3. *YEAR 1 2013 break crop yield/dry matter (t/ha) and gross margin ($/ha)*

Break Crop Sown 2013	YEAR 1 2013 Yield t/ha	YEAR 1 2013 DM t/ha	YEAR 1 2013 Gross Margin ($/ha)
Sub clover	-	10.4	1097
Beans	3.8	-	934
Peas (winter sown)	4.5	-	922
Wheat (grain)	3.9	-	419
Canola (grain)	1.7	-	180
Peas (spring sown)	1.7	-	178
Barley (spring sown)	1.8	-	69
P value	<.001	-	<.001
l.s.d (P<0.05)	0.9	-	447

Q2. Are sequences including break crops more profitable than continuous wheat?

- **Naracoorte Experiment 1**
- **Naracoorte Experiment 2**

Across all seasons (over a three-year period) the most profitable rotations tended to be those where initially a break crop was utilised, compared to continuous cereals.

The sequences that included winter legume species as break crops were more profitable than continuous wheat across all years.

Based on 75 kg N/ha being applied on the year 2 wheat crop, sub clover (hay) was the most profitable break crop option over the life of the project, being the most profitable rotation across all Phases. Peas - winter sown and beans were the next most profitable, followed by canola grain, all more profitable than continuous cereal rotations. The spring sown break crops were not as profitable as continuous cereals.

The benefit of a break crop was emphasized when the following wheat crop was sown early (before wheat on wheat rotation) in the seeding program.

When evaluated the canola and wheat 'grain and graze' treatments suffered no yield penalty post grazing when grazed within the 'safe' period. Grazing of these crops should follow best management guidelines.

Overall disease levels were low during the trials, but the results highlight the potential for cereal on cereal rotations to have an increased risk of take all, root rot and crown rot.

Of the break crops safflower had the highest plant available water capacity, giving it a greater ability to extract soil water moisture from the profile. This capacity tended to have a negative effect on subsequent yields and quality. Water use efficiency of the wheat crop tended to be greater following a winter sown pea, bean and sub clover break crop. Post break crop harvest soil moisture levels tended not to vary between break crops.

Cumulative gross margins, for Experiment 1, are presented in Table 4 with a significant interaction between 2011 break crop and gross margin recorded. The highest gross margin on average was $2278 with the break crop sub clover hay, which is significantly higher than all other gross margin averages. Peas - winter sown and canola - grain were the next best performing treatments on average. The wheat on wheat treatments performed between $1245/ha - $1127/ha, similar to the safflower and spring sown barley treatments.

Over the two year rotation, at the 75 kg N/ha treatment, the sub clover cut for hay returned the highest gross margin - $2264/ha; this was higher than all other treatments. Peas – winter sown, and canola – grain, had the second highest gross margins. Peas – winter sown had an increase of $549/ha in gross margin compared to spring sown peas. The lowest gross margins tended to be the cereal on cereal treatments.

Table 4. *Cumulative gross margin ($/ha) – YEAR 1 2011 break crop + YEAR 2 2012 wheat TOS 1 (2012 N application rate x 2011 break crop).*

Cumulative gross margin ($/ha) – YEAR 1 2011 break crop + YEAR 2 2012 wheat TOS 1					
Break Crop	YEAR 2 2012 wheat N application rate				
Sown 2011	25	50	75	100	
Sub clover (hay)	2248	2357	2264	2243	**2278**
Peas (winter sown)	1952	1871	1902	1736	**1865**
Canola (grain)	1827	1850	1881	1834	**1848**
Canola (grain and graze)	1758	1795	1739	1808	**1775**
Beans	1638	1593	1609	1614	**1614**
Canola (hay)	1484	1403	1384	1423	**1424**
Peas (spring sown)	1422	1258	1353	1293	**1332**
Wheat (0.3 m rows)	1159	1329	1362	1129	**1245**
Barley (spring sown)	1187	1236	1152	1220	**1199**
Wheat (grain and graze)	1178	1147	1202	1183	**1178**
Wheat (grain)	1156	1134	1087	1129	**1127**
Safflower (spring sown)	1201	1124	1082	1092	**1125**
Mean	**1518**	**1508**	**1501**	**1475**	

	P value	l.s.d (P<0.05)
2012 N Treatment	0.189	NS
2011 Break Crop	<0.001	96
N Treatment X Break Crop	1.000	NS

Over the three-year rotation, on average the TOS 1 gross margins were significantly greater than TOS 2, $2857/ha compared to $2720/ ha. The 2011 break crop had a significant interaction with the cumulative gross margin, with the most profitable break crop on average being sub clover at $3608/ha over the three year rotation, and the least profitable was wheat - grain at $2354/ha. Nitrogen application rate did not significantly interact with the cumulative gross margin. The most profitable rotation was - sub clover X wheat + TOS 1 + 50 kg N/ha X barley, $3827/ha.

Q2 - Naracoorte Experiment 2

In the second year of Experiment 2 (2014) there was no significant interaction between wheat yield and N rate application; therefore applying additional N didn't increase yields. This was reflected in the gross margins, with the added input cost of N and no increase in yields significantly decreasing returns. After two years, the cumulative gross margins were significantly different between break crops, with sub clover hay ($1312/ha), peas winter sown ($1211/ha) and beans ($1187/ha) being the most profitable over the two years. Barley spring sown ($261/ha) was the least profitable.

Local farm practice considers 75 kg N/ha (i.e. Year 2 wheat treatment) as standard management and as such the three year cumulative gross margins for these treatments only are shown in Table 5.

Table 5. *YEAR 3 2015 barley yield (t/ha), gross margin ($/ha) and cumulative gross margin (2013 + 2014 + 2015) – results from wheat plots with treatment 75 kg N/ha only.*

Break Crop Sown 2013	YEAR 3 2015 Barley yield (t/ha)	YEAR 3 2015 Gross Margin ($/ha)	Cumulative Gross Margin ($/ha) 2013 + 2014 + 2015
Sub clover (hay)	1.7	-148	1109
Beans	1.8	-112	1084
Peas (Winter Sown)	1.8	-122	1025
Wheat	1.8	-117	586
Peas (Spring Sown)	2.1	-44	387
Canola	1.9	-97	353
Barley (Spring Sown)	1.6	-154	79
P value	0.542	0.542	0.036
l.s.d (P<0.05)	NS	NS	698

Q3. What effects do break crops have on soil nitrogen availability?

- **Naracoorte Experiment 1**
- **Naracoorte Experiment 2**

On average across all break crop seasons beans had the highest level of N fixation, averaging 13 kgN/tDM produced.

Post-harvest, legume break crops had higher residual mineral N when compared to wheat and canola grain crops (Table x). This trend was observed after both the wheat and barley rotations (Table 3), suggesting the benefits of a legume break crop residual mineral N can last more than one season.

Under favourable seasonal conditions break crop treatments resulted in significantly higher subsequent wheat yields, regardless of the nitrogen treatment applied.

In dry spring conditions (Experiment 2, Year 2 (2014)) and subsequent lower wheat yield the impact of the legume break crop was not significant, although the rotations including beans and peas out-yielded the wheat on wheat rotation. Under these conditions there was no interaction between wheat yields and N treatment applied.

Across all seasons on average the wheat on wheat rotation had lower protein % and plump grain (>2.0 mm) %, compared to the legume break crop rotations.

In Year 3 of each of the experiments there was a significant interaction between barley yields X previous year wheat nitrogen application rate X initial break crop, again supporting the finding that the break crop influence can last more than one season.

Q3 - Naracoorte Experiment 1

Soil mineral N following all legume break crops grown in Year 1 of Experiment 1 (2011) were all significantly higher than the wheat (grain) treatment (Table 6).

Table 6. *Experiment 1 Mineral N (kg N/ha) 0-60 cm pre-sowing YEAR 2 2012 wheat crop. Arranged in descending order of Mineral N.*

Break Crop Sown 2011	Mineral N 2012 (kg N/ha) 0-60cm
Peas (spring sown)	139
Sub clover (hay)	134
Beans	125
Peas (winter sown)	111
Wheat (grain and graze)	109
Canola (grain and graze)	106
Barley (spring sown)	103
Wheat (0.3 m rows)	98
Canola (grain)	93
Safflower (spring sown)	87
Wheat (grain)	81
Canola (hay)	55
P value	<0.001
l.s.d (P<0.05)	20

Q3 - Naracoorte Experiment 2

The Mineral N results from the three year period for selected treatments in Experiment 2 (Table 7) highlight that after two subsequent cereal crops the Beans treatment still had significantly higher soil mineral N than any of the other treatments.

Table 7. *Mineral N post-harvest (kg N/ha) 0-60 cm, Year 1 all treatments, Year 2 and Year 3 from treatments with 75 kg N/ha applied in 2014. Arranged in descending order of 2015 Mineral N.*

Break Crop	Mineral N (kg N/ha) 0-60 cm		
Sown 2013	May-14	Dec-14	Dec-15
Beans	175	94	116
Peas (winter sown)	148	84	69
Canola	123	110	64
Sub clover (hay)	144	110	61
Peas (spring sown)	148	86	57
Barley (spring sown)	84	66	54
Wheat	105	50	45
P value	0.028	0.002	<0.001
l.s.d (P<0.05)	47	25	18

APPENDIX

- For the full report go to: http://www.mackillopgroup.com.au/media/111%20Flyers%20KM/Final%20Report%20Project%20CSP00146%20Feb16.pdf

ACKNOWLEDGMENTS

- David and Felicity Miles for hosting the long-term trial for five years
- Trent Potter, Yeruga crop research
- SARDI New Variety Agronomy Team, Struan
- Heritage Seeds
- CSIRO Crop Sequencing Project Team; Mark Peoples, Laura Goward, Tony Swan, Julianne Lilley and James Hunt.