CROP SEQUENCING TRIAL

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PROJECT DURATION: 2011-2015

KEY MESSAGES

- Time of Sowing; get it right after the break crop.
- Effects of the break crops are often realised for at least 2 seasons after being planted.
- Beans consistently fixed the most nitrogen over the 3 year period; averaging 15Kg N/ha per tonne of dry matter produced (above the ground).
- Financial benefit of a break crop needs to be worked out over life of rotation.

Figure 1: Break crop site layout at Lochaber Crop Sequencing site

Background

The Crop Sequencing project aims to explore and quantify the benefits of broadleaf species in crop rotations in the South East region of South Australia, with the aim of increasing water use efficiency of these crops and the subsequent cereal crops.

The trial was established at Lochaber; The first rotation sown to a break crop was established in 2011 (Phase 1) and new 'phases' of break crops were established at the trial site in subsequent years, 2012 (Phase 2) and 2013 (Phase 3).

Break crops sown in all three phases included Canola, Beans, Winter sown and spring sown peas and antas sub-clover.
In Phase 1 and Phase 2 some additional break crops were evaluated, including spring sown safflower, canola for grain and graze and canola for hay. Wheat and spring sown barley was also planted at the same time as the break crops to compare the effect of the break crop rotation to a cereal on cereal rotation. In Phase 1 wheat was also sown as wide rows and for grain and graze.

In the second year of each phase, wheat was sown down across all break crop plots; the management of these wheat plots was adjusted between the phases, with Phase 1 wheat management initially focusing on time of sowing and nitrogen rates, and Phase 2 and 3 focusing on nitrogen management (application rate and timing).

In the third year of Phase 1 and Phase 2 barley has been sown down with consistent management across all plots (time of sowing and nitrogen management). This will allow for impacts of previous management regimes to become evident.

Methodology

Table 1 summarises the break crops sown for each Phase, followed by the wheat rotation and the different management regimes implemented, and thirdly the barley rotation. All treatments were replicated. The initial break crops were sown as larger blocks and then split into sub-plots for the wheat sowing. The barley in the third year was sown on top of the wheat plots. Break crop harvest yields, soil moisture and soil nitrogen were measured in each plot. All wheat and barley plots were measured for harvest yield.
In each phase, once the break crop plots were sown down to wheat, only the 75kg/ha nitrogen treatment plots were sampled for soil moisture and soil nitrogen. Phase 1 and Phase 3 break cropw were sown onto farmer cereal stubbles; Phase 2 was sown onto a farmer bean stubble.

Table 1: Treatments/year

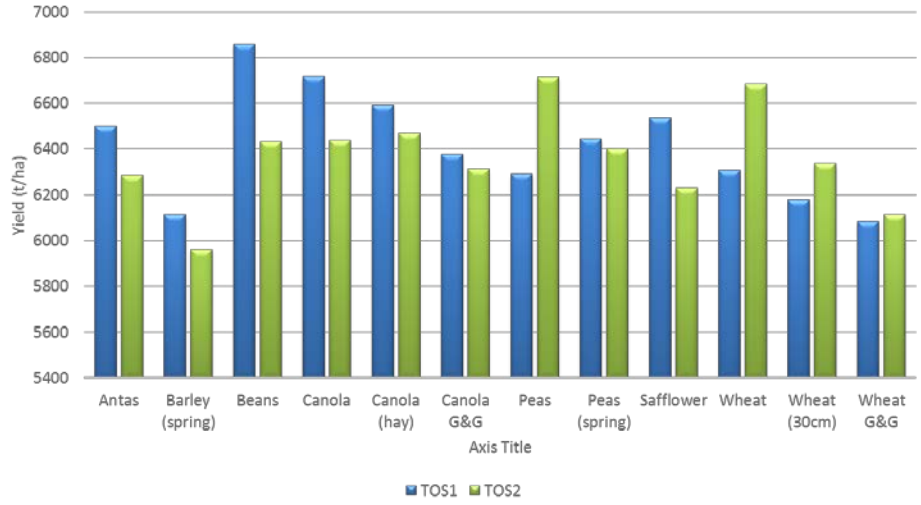
Phase 1			Phase 2			Phase 3		
2011 (Y1)	2012 (Y2)	2013 (Y3)	2012 (Y1)	2013 (Y2)	2014	2013 (Y1)	2014	2015
Antas sub-clover	Wheat TOS1 x 4N rates	Barley	Antas sub-clover	Wheat x 4N tmts	Barley	Antas sub-clover	Wheat x 4N tmts	Barley
	Wheat TOS2 x 4N rates	Barley		Wheat x 2N tmts split	Barley		Wheat x 2N tmts split	Barley
Barley (spring)	Wheat TOS1 x 4N rates	Barley	Barley (spring)	Wheat x 4N tmts	Barley	Barley (spring)	Wheat x 4N tmts	Barley
	Wheat TOS2 x 4N rates	Barley		Wheat x 2N tmts split	Barley		Wheat x 2N tmts split	Barley
Beans	Wheat TOS1 x 4N rates	Barley	Beans	Wheat x 4N tmts	Barley	Beans	Wheat x 4N tmts	Barley
	Wheat TOS2 x 4N rates	Barley		Wheat x 2N tmts split	Barley		Wheat x 2N tmts split	Barley
Canola (grain)	Wheat TOS1 x 4N rates	Barley	Canola (grain)	Wheat x 4N tmts	Barley	Canola	Wheat x 4N tmts	Barley
	Wheat TOS2 x 4N rates	Barley		Wheat x 2N tmts split	Barley		Wheat x 2N tmts split	Barley
Canola (hay)	Wheat TOS1 x 4N rates	Barley	Canola (hay)	Wheat x 4N tmts	Barley	Peas (spring)	Wheat x 4N tmts	Barley
	Wheat TOS2 x 4N rates	Barley		Wheat x 2N tmts split	Barley		Wheat x 2N tmts split	Barley
Canola G&G	Wheat TOS1 x 4N rates	Barley	Canola G&G	Wheat x 4N tmts	Barley	Peas (winter)	Wheat x 4N tmts	Barley
	Wheat TOS2 x 4N rates	Barley		Wheat x 2N tmts split	Barley		Wheat x 2N tmts split	Barley
Peas (spring)	Wheat TOS1 x 4N rates	Barley	Peas (spring)	Wheat x 4N tmts	Barley	Wheat	Wheat x 4N tmts	Barley
	Wheat TOS2 x 4N rates	Barley		Wheat x 2N tmts split	Barley		Wheat x 2N tmts split	Barley
Peas (winter)	Wheat TOS1 x 4N rates	Barley	Peas (winter)	Wheat x 4N tmts	Barley	*NB. Safflower was removed due to issues with bird control in both Phase 1 and Phase 2.		
	Wheat TOS2 x 4N rates	Barley		Wheat x 2N tmts split	Barley			
Safflower (spring)	Wheat TOS1 x 4N rates	Barley	Safflower (spring)	Wheat x 4N tmts	Barley	Other treatments in Phase 1 and Phase 2 were included under the Grain&Graze project which ended in 2013.		
	Wheat TOS2 x 4N rates	Barley		Wheat x 2N tmts split	Barley			
Wheat (grain)	Wheat TOS1 x 4N rates	Barley	Wheat (grain)	Wheat x 4N tmts	Barley			
	Wheat TOS2 x 4N rates	Barley		Wheat x 2N tmts split	Barley			
Wheat (wide rows)	Wheat TOS1 x 4N rates	Barley	* NB. Only 1 TOS was utilised for Phase 2 and 3; this decision was made based upon the results of Phase 1 being consistent with findings from the GRDC funded project MFM003 "The Water Use Efficiency project".					
	Wheat TOS2 x 4N rates	Barley						
Wheat G&G	Wheat TOS1 x 4N rates	Barley						
	Wheat TOS2 x 4N rates	Barley						

Results and Discussion

The 2014 season saw the completion of two full rotations; Phase 1 and Phase2 that have been evaluated for 3 years each.
At the conclusion of the rotation; Phase 1 was showing significant combined effects of both the break crop in year 1, and the time of sowing of wheat in year 2. Figure 2 compares 2013 barley yields from the different break crop plots (sown in 2011) and from two different wheat times of sowing (TOS1 and TOS2), but with the same nitrogen application rate of 75Kg N/ha (sown year 2, 2012). The beans and canola break crops followed by wheat at time of sowing 1 are still showing significant yield benefits when compared with the other break crops and TOS1.

The same effect of break crop after 3 years was not seen in Phase 2; this is thought to be due to both the lack of late-winter and spring rainfall, and also due to the initial year of Phase 2 being planted on a bean stubble.

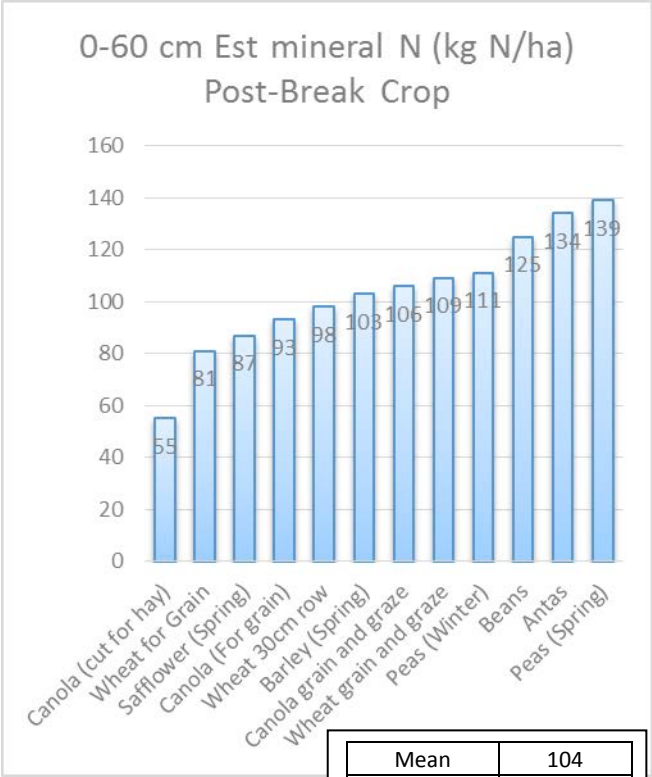
Graph 1: Carry over effects of Break Crop and time of sowing on Barley Yield in 2013



The subsequent increased yields in wheat and barley following a break crop, are thought to be due to a combination of factors; an increase in soil moisture after a break crop (compared to a wheat crop) and the additional nitrogen supplied in the case of pulse break crops.

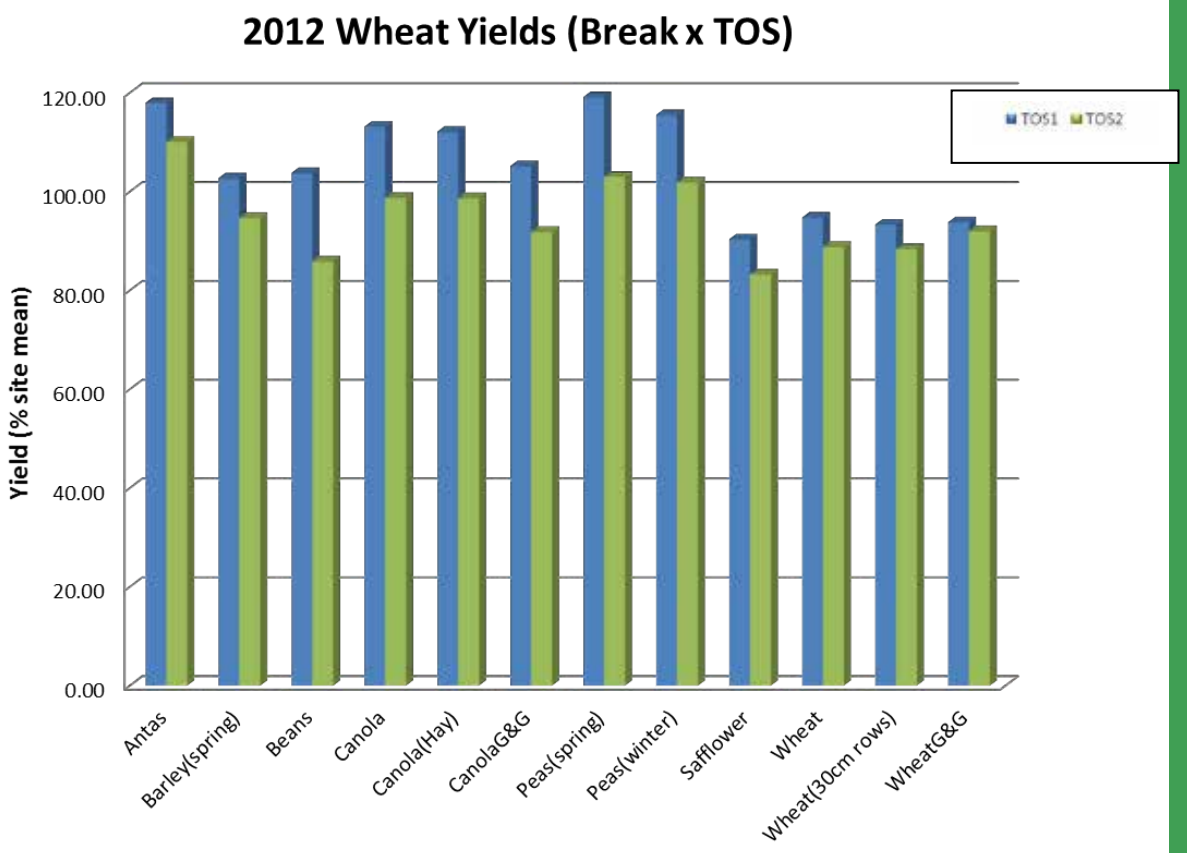
In Phase 1, wheat yield increases after the break crop (at 75kg/ha N application) is shown in Graph 2. Soil moisture and soil nitrogen results suggest that the wheat crop was able to utilise the additional soil moisture left over after the break crop, and also the additional nitrogen that was put back into the system.
The safflower showed a suppressed yield in the subsequent wheat crop; possibly a result of the high moisture extraction by the safflower over the summer period, resulting in a lower soil moisture available for the wheat crop when compared to other break crops. Graph 3 shows the amount of soil nitrogen in the soil prior to sowing the wheat crop, supporting the idea of pulse/legume break crops having the capacity to provide soil N to subsequent cereal crops.

Graph 3: Soil mineral nitrogen (0-60cms) post-break crop



Mean	104
P(<0.05)	<.001
l.s.d.	20.2
cv%	6.5

Graph 2: Phase 1, Year 2 Wheat Yields



2012

Table 2: Year 1 yields across all phases

	Phase 1 (2011)		Phase 2 (2012)		Phase 3 (2013)	
Entry	**Biomass (t/ha)**	**Grain yld (t/ha)**	**Biomass (t/ha)**	**Grain yld (t/ha)**	**Biomass (t/ha)**	**Grain yld (t/ha)**
Antas sub-clover	7.55		6.04		10.36	
Barley (spring)		2.96		0.78		1.83
Beans		2.66		2.09		3.84
Canola (grain)		2.29		1.72		1.67
Canola (hay)	8.4		9.07			not evaluated
Canola G&G	1.05	2.24	1.53	1.24		not evaluated
Peas (spring)		1.44		0.50		1.74
Peas (winter)		3.13		2.83		4.49
Safflower (spring)		1.41		*		not evaluated
Wheat (30cm rows)		3.51		not evaluated		not evaluated
Wheat (grain)		4.00		4.07		3.94
Wheat G&G	0.47	3.75		not evaluated		not evaluated

Phase 3 was established with break crops in 2013. The Antas sub-clover produced large levels of biomass in 2013. The summary of yields and / or dry matter production for the break crops is shown in Table 2. Even in the dry spring experienced in year 2 of Phase 3, there were significant differences in yield response between the break crop treatments

(shown in Table 3) and subsequent wheat yields. Wheat yields post legume crops or pastures all yielded significantly higher than those following a barley or canola crop. In this season, there wasn't a significant difference in wheat yields following either a wheat or a bean break crop. Phase 3 will be carried through for a final year to establish if the effects of the break crops are observed again after three years (as has been observed in Phase 1).

Table 3: Phase 3 2014 Wheat yield and pre-sowing (0-60 cm) estimated mineral N (kg N/ha) (post 2013 breakcrop)

Break Crop in 2013	Wheat 2014 yield (kg/ha)	mineral N (kg N/ha)
Canola	2486	122.5
Barley (Spring)	2671	83.6
Wheat	2894	104.5
Antas	2927	143.9
Beans	3063	175.4
Peas (Spring)	3220	148.3
Peas (Winter)	3318	147.6
MEAN	2940	132.2
P(0.05)	<0.001	0.028
l.s.d.	302	46.82
cv%	-	7.7

Figure 2: Measuring Crop Lower Limits in beans:

Throughout the life of the project, various soil water measurements were taken (See Figure 2); this included the measurement of crop lower limits at the end of Phase 1, Year 1. This information will be fed back into the soil water database, allowing us to better understand the extraction of moisture in these soils by those crops for which crop lower limits were sampled.

All legume crops that were utilised as break crops were sampled each year to measure the amount of nitrogen fixed. Over the life of the project, the beans were the most consistent; fixing an average of 15Kg nitrogen/ha/tonne of above ground dry matter produced.
This project ends at the end of this year; the full report with economic analysis, and analysed soil moisture and water data will be made available at this time.

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