Break crops for the Mallee

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Take home messages

- *Canola produced the highest gross margin of all break crops grown in 2010.*
- *Wheat grown following peas and vetch had the highest grain yields and protein concentrations.*
- *Crop sequences of canola, pea grain or hay and vetch hay followed by wheat have gross margins equal to or higher than wheat-wheat and fallow-wheat on both sand and clay soils.*

Background

Wheat grown in rotation with broad-leaf break crops often yields better than that grown in exclusively cereal-based rotations. Benefits from break crops include nitrogen fixation (legumes), passive and (in the case of brassicas) active control of root and foliar diseases and the opportunity to control weeds with a wider range of herbicides. The disadvantages of many break crops are that they are not as profitable and are harder to market than cereals, more difficult and expensive to grow and are less resilient in dry seasons (higher risk). The aim of this experiment is to evaluate the risk and profitability of different break crops in the Mallee and their alternate end-uses (e.g. hay, grain, brown manure). It also quantifies the impact of each crop type and end-use on subsequent wheat yield. This five year project is now in its second year. The first year of results can be found on page 39 of the 2009 edition of BCG Research results.

Aim

To identify low-risk, profitable break crops for the Mallee region and quantify their benefits to subsequent wheat crops.

Method

This experiment was established 13km south-east of Hopetoun on Warrakirri's *Bullarto Downs* property and was repeated on two different soil types typical to the region, 2km apart. The sand site lay on top of an east-west dune with sandy topsoil and clay subsoil. The clay site was located on a low-lying flat with clay loam topsoil and moderate subsoil constraints.

Plots (2.1 x 28m) were pegged out in three separate areas in December 2008 using a split block randomised design with four replicates. The first area was planted to break crops (listed in Table 1) in 2009, followed by wheat in 2010. It will be sown again to wheat in 2011 and 2012. The second area was sown to wheat in 2009, to break crops in 2010, to be followed by wheat in 2011 and 2012. The third area was sown to wheat in 2009 and 2010 and will be sown to break crops in 2011 and wheat in 2012.

Location:	Hopetoun
Replicates:	4
Blocks	3
Sowing date:	Various (refer Table 1)
Seeding density:	Various (refer Table 1)
Crop type/s:	Oasis juncea, GT Scorpion canola, Morgan peas, Correll wheat, chemical fallow, Morava vetch
GSR:	264mm
Seeding equipment:	knife points, 30cm, press wheels
Fertiliser:	55kg/ha MAP
Soil fertility:	Sand site: 21mg/kg Colwell P, 35 PBI
	Clay site: 33mg/kg Colwell P, 147 PBI

Table 1. 2010 break crop and sowing details

Treatment	Variety	Sowing date	Sowing rate (kg/ha)	Target density (plants/m^2)	N fertiliser	End use *
Juncea	Oasis	29 April	2.5	70	28 July, 36kgN/ha	Hay (4.11.10) & grain
Peas	Morgan	2 June	80	40	-	Hay (5.10.10) & grain
Wheat	Correll	29 April	67	130	15 June, 27kgN/ha 28 July, 37kgN/ha	Hay (5.10.10) & grain
Fallow	Chemical	-	-	-	-	Long (1.7.10) & short fallow (1.9.10)
Vetch	Morava	29 April	100	60	-	Hay (5.10.10) & brown manure (7.9.10)

** End use – date in brackets indicates date hay was cut or treatment was implemented.*

Two soil cores per plot (segmented into layers to a depth of 1.3 m) were taken on 12 November 2009, 30 March 2010 and 14 December 2010.Plant available water and mineral nitrogen were determined on the samples. The soil water content measured in cores sampled in November 2009 was assumed to be a good indication of crop lower limit (CLL) and was used to calculate plant available water (PAW).

Two cores were taken per plot to a depth of 10cm pre-sowing on 31 March and were tested for DNA levels of soil-borne disease inoculum (Predcita B testing).

Correll wheat (67kg/ha) was sown over the area occupied by the 2009 break crops on 29 April 2010. Plots were top dressed with 25kgN/ha as urea on 15 June and 37kgN/ha as urea on 28 July 2010.

Dry matter production was measured at flowering and at maturity in all crops. Half of each of the 2010 break crop plots was cut for hay at an appropriate time for each crop (biomass cut at approximately 10 cm above ground level and removed from plots) and for vetch, half of each plot was brown manured. The other half of all the plots were machine harvested for grain yield and the grain analysed for quality (protein, oil, moisture, and screenings).

Total amounts of N fixed were derived from shoot data (N15 analysis) by assuming plant N was partitioned 67% above-ground, 33% below-ground in nodulated roots.

Gross margins were calculated for each crop and end-use in both 2009 and 2010. Hay prices were assumed to be $130/t for vetch and mustard, $125/t for wheaten hay and $135/t for pea hay. Grain prices used were $222/t for wheat, $514/t for canola and $245/t for peas. The variable costs used to calculate the gross margins include cutting $25/ha, bailing $24/t, urea $530/t and MAP $905/t.

Results

Break crop production in 2010

In 2010, juncea failed to establish at both sites. This seems to be a recurring problem with this crop. Because of this and consistently poor yields relative to canola, it will be replaced with canola for the remainder of the experiment. In order to provide a fair comparison of how canola performed relative to other break crops in 2010, the yield and dry-matter results of the GT Scorpion canola crop in the standing stubble treatment of the adjacent moisture conservation experiment (see article on page 30 for details) are presented here. However, be aware that the canola hay and yield results are not included in statistical tests.

Hay and grain yield varied substantially for each crop at the clay site (Table 2). Wheat yielded 0.5t/ha higher on the clay site but peas were more suited to the sandy soil type in 2010.

Table 2. Mean hay yield, 30 September 2010 (at 70% flowered) canola, 5 October (wheat, peas and vetch). ANOVA does not include canola.

Crop	Yield (t/ha)			
	Sand		Clay	
	Hay	Grain	Hay	Grain
Peas	5.1	3.4	2.4	1.4
Wheat	6.8	4.4	6.0	4.9
Vetch	5.9	-	3.9	-
P Value **LSD (P=<0.05)** **CV%**	**P=<0.01** **1.1** **12.7%**	**P=0.076** **NS** **18%**	**P=<0.01** **0.9** **15.1%**	**P=0.005** **1.0** **13.8%**
Canola	3.7	3.3	2.7	2.7

Hay yields were assumed to be 60% of dry matter for vetch and 70% of dry matter for canola, peas and wheat (at 13% moisture). Grain yield for wheat is at 11.5% moisture. Canola hay and grain yields are from the standing stubble treatment of moisture conservation trial and are not included in the statistical analysis.

Canola grain (Table 3) produced the highest gross margin at the sand site ($1448/ha) and wheat grain produced the highest gross margin at the clay site, ($1264) closely followed by canola grain ($1146/ha). Amongst the hay crops, vetch and wheat had the highest gross margins.

Table 3. Mean gross margin for all crops grown in 2010 at sand and clay sites (for grain prices please refer to the methods section)

Crop	Gross Margin ($/ha)			
	Sand		Clay	
	Hay	Grain/other	Hay	Grain/other
Canola	$127	$1448	$51	$1146
Peas	$319	$661	- $7	$182
Wheat	$352	$788	$245	$1264
Vetch	$374	- $12 ***	$178	- $12 ***
Fallow	- $12 **	- $25 *	- $12 **	- $25 *

Fallow Long, ** Fallow Short, * Vetch brown manure treatment*

Both peas and vetch fix considerable amounts of nitrogen which has the potential to benefit subsequent crops (Table 4). No differences were observed between crop types in terms of amount of nitrogen fixed, although less nitrogen was fixed at the clay site. This was because of the lower dry matter production and higher concentrations of soil mineral nitrogen in the clay soil at sowing (see below).

Table 4. Mean total fixed nitrogen kg N/ha

	Total fixed nitrogen (kg N/ha)*	
	Sand	Clay
Peas	125	48
Vetch	130	77
P Value	**P=0.609**	**P=0.079**
LSD (P=<0.05)	**45**	**34**
CV%	**15.7%**	**24.6%**

** Estimates of total amounts of N fixed were derived from shoot data by assuming plant N was partitioned 67% above-ground, 33% below-ground in nodulated roots.*

What is the effect of break crops on subsequent wheat production?

At the sand site, the different crop types and end-uses grown in 2009 resulted in different amounts of soil mineral nitrogen being available at the start of the 2010 growing season (Table 5). Peas harvested for grain, brown-manured vetch and short fallow returned the greatest amount of nitrogen, while canola, juncea, wheat and long fallow provided the least. The lower value of long fallow relative to short fallow is possibly due to leaching of nitrate during the summer months. The high rainfall in 2010 may have contributed to leaching.

At the clay site, preceding crop type, but not end-use, affected the amount of available nitrogen, with peas contributing the most for the 2010 wheat crop. More nitrogen was available after wheat and juncea, relative to canola, due to lower yields and hence lower nitrogen removal in 2009 (see 2009 results for details).

Table 5. Soil mineral nitrogen at the sand site after various treatments in 2009 measured in March 2010 and at the clay site

2009 treatment	Sand site Soil mineral nitrogen (kg N/ha)		Clay Site Soil mineral nitrogen (kg N/ha) Mean for each crop type
	Grain	Hay/other	
Canola	77	73	152
Juncea Canola	88	76	239
Peas	124	94	309
Wheat	86	102	223
Vetch	139***	108	265
Fallow	80*	127**	229
P Value	**P=<0.001**		**P=<0.01**
LSD (P=<0.05)	**26**		**52**
CV%	**18.2%**		**22%**

Long fallow, **Short Fallow, * Brown manure Vetch*

DNA analysis showed that inoculum levels of soil borne diseases were low at both sites. The only significant effect of crop type was at the clay site, where crown rot inoculum was found to be lower after juncea than wheat or fallow (Table 7). Symptoms of take-all, rhizoctonia and crown-rot were observed at both sites, but not at levels sufficient to affect yields. Crown rot values of 2pg DNA/g soil or below are considered to be low risk category for bread wheat production (table 7). However none of the sampling has returned any high risk results.

Table 7. The effect of crop sown during 2009 at the clay site on crown rot inoculum levels in April 2010

Crop	Crown Rot ***(F. pseudograminearum)*** pg DNA/g soil
Juncea	1.56 a
Canola	1.68 ab
Pea	1.72 ab
Wheat	2.13 bc
Fallow	2.28 c
P Value	**0.05**

Data presented in table 7 is shown to log scale and is the same as values given out in Predicta B soil testing.

Because root diseases and water availability did not limit growth in 2010, differences in soil nitrogen created by the different crops were the major determinant of yield and protein responses, with wheat preceded by vetch and peas yielding significantly more than the other crop types at the sand site (Table 8). There was no significant effect of previous crop type on wheat yield at the clay site and no significant effect of end-use of the break crop on wheat yield at either site. At the sand site, wheat grain protein was higher following peas (Table 8), and

cutting 2009 crops for hay also resulted in significantly higher wheat protein in 2010 (9.6% vs. 9.1% for grain, P=0.003). At the clay site wheat protein was highest after peas, reflecting the higher levels of mineral N.

Table 8. Mean 2010 wheat yield when grown following various crops or fallow in 2009

2009 Crop	Sand		Clay	
	Wheat yield (t/ha)	Grain protein (%)	Wheat yield (t/ha)	Grain protein (%)
Canola	4.8	8.9	5.6	10.5
Juncea Canola	5.0	9.0	5.7	11.2
Peas	5.5	10.0	6.0	11.5
Wheat	4.7	9.4	5.7	10.7
Vetch	5.4	9.3	5.7	11.0
Fallow	5.0	9.4	6.0	11.3
P Value	**P=<0.001**	**P=0.003**	**P=0.291**	**P=<0.01**
LSD (P=<0.05)	**0.3**	**0.53**	**NS**	**0.46**
CV%	**5.4%**	**1.8%**	**7.3%**	**4.1%**

Canola (grain), juncea (grain), pea (hay) and vetch (hay) produced the most profitable crop sequence when grown prior to wheat over the two years at the sand site (Table 9). Hay or grain treatments in 2009 did not have a significant impact on the two-year gross margin at either site. There was a difference in crop type: pea hay followed by wheat resulted in the highest mean two year gross margin at both sites.

Table 9. Mean two year gross margin ($/ha) when various treatments imposed in 2009 were followed by wheat in 2010.

2009 Crop	Sand Two year Gross Margin 2010 Wheat Grain following:		Clay Two year Gross Margin 2010 Wheat Grain following:	
	2009 Grain ($/ha)	2009 Hay ($/ha)	2009 Grain ($/ha)	2009 Hay ($/ha)
Canola	$1494	$1009	$1566	$1495
Juncea	$1362	$1128	$1378	$1426
Peas	$1238	$1413	$1536	$1865
Wheat	$1010	$1029	$1408	$1318
Fallow	$1031 **	$1068 *	$1403 **	$1576 *
Vetch	$1244 ***	$1453	$1081 ***	$1438

*** Long fallow, * short fallow, *** Vetch brown manure,*

Interpretation

Break crop production 2010:

Under low root disease pressure, canola was the only break crop that could match the profits of wheat in 2010. However, vetch and pea crops both contributed significant amounts of nitrogen, which may benefit the cereal phase in 2011. Establishment problems and poor yield performance of juncea at this site resulted in canola being used as the brassica. Further work should identify juncea varieties that may be more reliable.

Effect of break crops on subsequent wheat production:

Wheat growing on pea and vetch stubbles was able to achieve higher yields and proteins due to the nitrogen provided by these break crops. Low disease pressure in 2010 meant that wheat following wheat still yielded well. At the sand site, canola and juncea grain, pea hay and vetch hay followed by wheat were all more profitable than the controls of wheat-wheat or fallow-wheat. At the clay site, pea hay-wheat was by far the most profitable sequence, and pea grain and canola grain and hay followed by wheat also out-performed wheat-wheat, but were equivalent to short fallow-wheat.

At both sites, sequences of canola-wheat, pea hay or grain-wheat and vetch hay-wheat were profitable relative to wheat-wheat and fallow wheat and the different benefits associated with these crops need to be considered. The advantage of canola is its high value, whilst the advantages of vetch and peas are their inputs of fixed nitrogen and subsequent contributions to soil fertility.

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