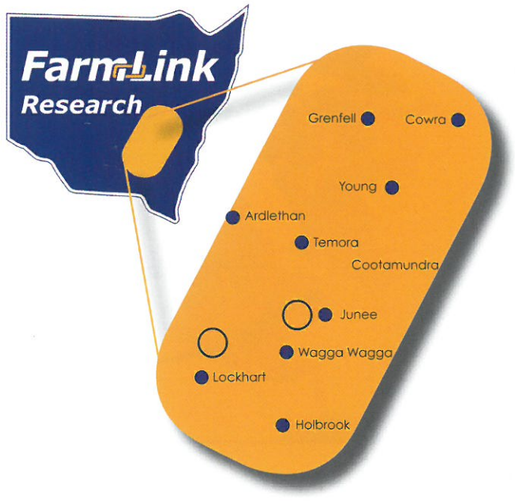
FarmLink
Research Report 2012

04

Crop Sequencing

2012 Trial Site



Project Partners

FarmLink Research

CSIRO

NSW GOVERNMENT Department of Primary Industries

Funded by

GRDC
Grains Research & Development Corporation

Crop Sequencing

Facilitating increased on-farm adoption of broadleaf species in crop sequences to improve grain production and profitability.

Background

As part of the GRDC funded project "Facilitating increased on-farm adoption of broadleaf species in crop sequences to improve grain production and profitability" FarmLink Research implemented two farmer sown trials, in collaboration with Mark Day and Steven Day at Lockhart and one small plot trial at Wagga Agricultural Research Institute in co-operation with NSW DPI and CSIRO. The trials looked at three specific aspects of brown manure pulses;

Trial 1: Brown manure peas compared to long fallow.
Trial 2: Brown manure peas followed by wheat or canola to improve weed control.
Trial 3: The impact on dry matter and grain production of pulses sown at various times.

Trial 1. Comparison of brown manure peas and long fallow north west of Lockhart.

Aim

To measure the impacts of brown manure peas on Nitrogen fixation, moisture conservation, weed control and yield compared to a traditional long fallow system.

Method

Using GPS guidance with a controlled traffic farming system, trial participants Steven Day and Mark Day sowed peas into wheat stubble that was developing herbicide resistant annual rye grass and wild oats.

As long fallow is still a valuable tool in the Lockhart area three strips were left unsown for the full length of the paddock with a 36m wide strip of peas in between. Each unsown strip was also 36m wide. This provided a replicated large scale farmer sown trial from which we could collect scientifically significant data in following years.

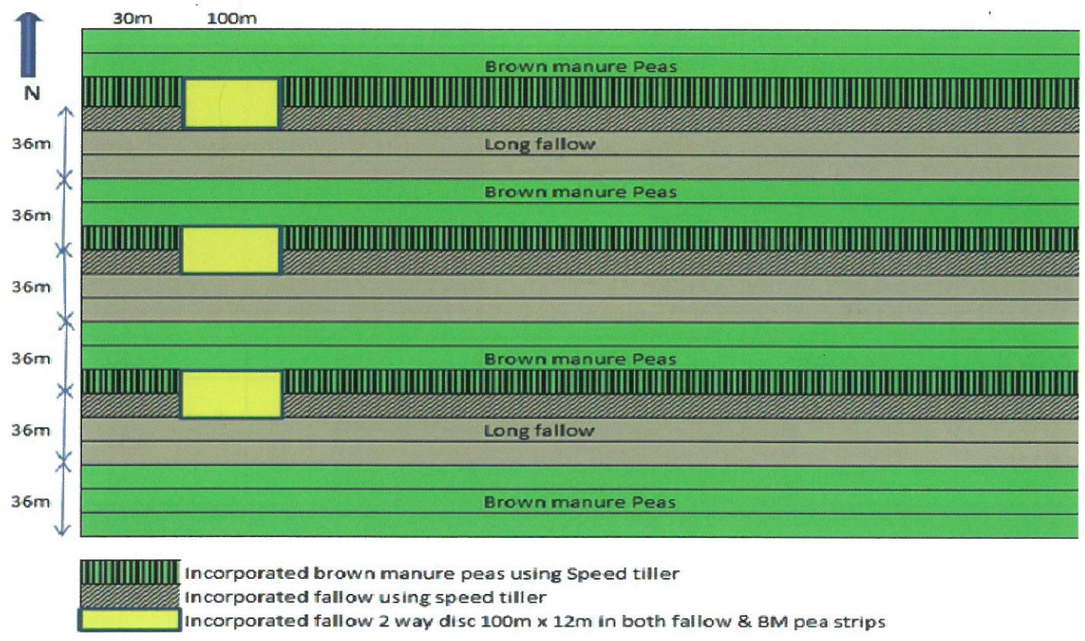


Figure 1: Trial plan for Lockhart.

Table 1. Site information for Lockhart.

Agronomy Details	Peas	Long Fallow
Soil Type	Brown Sandy loam over clay	Brown Sandy loam over clay
Rainfall Nov11-Mar12	415mm	415mm
Rainfall April-Oct 2012	119mm	119mm
Variety	Morgan	n/a
2011 crop	Wheat	Wheat
Sowing date 2012	10-April 2012	n/a
Seed Rate	100kg/ha	n/a
Initial soil N	45.8kg/ha	45.8kg/ha
Fertiliser	nil	n/a
Top Dress N	nil	n/a
Yield	nil	n/a

Table 2. Long fallow chemical applications 2012.

Date	Purpose	Product	Rate/ha	$ Cost/ha
23/7/12	Spring fallow	Round-up	1.5L	5.25
		Hammer	45ml	13.00
		LI700	250ml/100L	2.00
10/9/12	Knock down second germination	Round-up	1.5L	5.25
		LI700	250ml/100L	2.00
24/9/12	Double-knock	Gramoxone	1L	4.50
28/10/12	2nd double-knock	Gramoxone	1L	4.50
8/12/12	Fleabane	Round-up	1.5L	5.25
		Ester 680	500ml	4.30
		LI700	250ml/100L	2.00
24/12/12	Double-knock Fleabane	Gramoxone	1L	4.50
		LI700	250ml/100L	2.00
Total				**59.05**

Table 3. Brown manure Peas chemical applications 2012.

Date	Purpose	Product	Rate	$ Cost/ha
14/9/12	Pea knock down	Round-up	1.5L	5.25
		Lontrel	300ml	9.00
		LI700	250ml/100l	2.00
24/9/12	Pea double-knock	Gramoxone	2L	9.00
		Round-up	1.2L	4.20
		Ester 680	300ml	2.58
		LI700	250ml/100L	2.00
8/12/12	Summer fleabane	Round-up	1.5L	5.25
		Ester 680	500ml	4.30
		LI700	250ml/100L	2.00
24/12/12	Double-knock Fleabane	Gramoxone	1L	4.50
		LI700	250ml/100L	2.00
Total				**52.08/ha**

Dry matter cuts from the peas were conducted just prior to brown manuring. A lower than desired 2.6t/ha was recorded. Low dry matter in pulses has a direct relationship to N fixation and we expect lower than normal N levels pre sowing in 2013 as a result.

Photo 1: Peas v Fallow 13 June, 2012.

Photo 2: Peas establishment 13 June, 2012.

Photo 3: Fallow stubble and weeds.

It was decided to test the theory that brown manure when incorporated mineralises additional N compared to unincorporated. Work done by Alan Mayfield in SA indicated a yield increase from incorporating brown manure vetch. The peas were brown manured with double knock applications of Glyphosate and Gramoxone. The areas marked by yellow boxes in Figure 1. were then tilled with a two way disc. This area and the remainder of the incorporation treatment were incorporated using a K-line speed tiller.

Photo 4: Peas +/- speed tiller.

Photo 5: Fallow +/- speed tiller.

Photo 6: Peas post brown manure + speed tiller.

Photo 7: Fallow post speed tiller.

Photo 7: Speed tiller incorporating brown manure peas. Unincorporated in front, incorporated RHS.

Results

During the year data was collected for weed density, chemical applications and nitrogen fixation in the Morgan peas biomass. The aim of the trial is to establish variable costs over the four year period of the trial, the value of N from each treatment, impacts on soil moisture and the impact on weed densities. At time of writing there are no soil test results for 2013 but included is calculated N fixations from total plant biomass and N15 testing carried out on biomass collected in September 2012 prior to the first knock down application.

Establishment – 45plants / m^2

Weed densities – Weed data was collected on two dates;

1. 1st May 2012 – There was a very low number of weeds present and counting methodology would not have registered a significant score. Weeds identified at this early stage were clover, sow thistle, marsh mallow, fleabane (immature and mature), volunteer wheat, wild oats and annual rye grass. (ARG)

2. 5th November 2012 – Measuring the effectiveness of weed control by chemical and tillage applications in each of the treatments.

Overall the fallow without tillage contained higher weed densities than all the other treatments with Fleabane at 0.57 plants/m^2. The brown manure peas had very low levels of marsh mallow and milk thistle. Both speed tilled treatments were very clean.

Table 4. Weed densities.

Agronomy Information	Fallow plants/m^2	Fallow Inc. plants/m^2	BM peas plants/m^2	BM peas Inc. plants/m^2
1 = Fleabane	0.57	-	-	-
2= Marsh mallow	-	-	0.067	-
3 = Annual rye grass	-	-	-	-
4 = Lucerne	-	-	-	-
5 = Milk Thistle	-	-	0.1	-

Nitrogen fixation – Prior to sowing soil tests collected and analysed to a depth of 100cm. This soil is a brown sandy loam over clay with an alkaline sub soil. It is low in P (23mg/kg) and N (46kg/ha) with average organic C levels.

Table 5. Pre-sowing soil test results.

Depth (cm)	Moisture Content (g/g)	pH (1:5 water)	EC (uS/cm)	Available N (mg/Kg)	Available P (Cowell mg/Kg)	% Organic C
0 - 10	0.239	6.74	81.2	1.74	23.38	1.42
10 - 40	0.318	8.79	172	3.91	0.21	0.53
40 - 70	0.306	9.25	192.5	0.89	0.42	0.30
70 - 100	0.286	9.39	219	1.11	0.00	0.11

Biomass N fixation – 5 x 1m biomass cuts per replication were tested for N content and estimates of total plant N fixation were calculated 67kg N/ha. Past research has indicated all of this N is not available to the next crop. Medic research by Lada et al calculated 17% of legume N becomes available in the next year.

The brown manure peas were considered thinner than desirable and contained low levels of an unidentified disease (possibly bacterial blight). Common dry matter production in the region for Morgan peas ranges from 5-9t/ha. Wild oats were present in the crop and made it necessary to apply a knock down before peak biomass production had been reached to control weed seed set.

Costs of individual treatments – A vital component of the trial work is to establish economic impacts of various treatments. Initial costs have been listed below for operations carried out to date. (Costs were calculated using NSW DPI Budget Handbook and locally sourced prices).

Table 6. Brown manure vs long fallow cost comparisons.

Treatment	Operation	$/ha	Total $/ha 2012
Fallow	Chemicals 2012	59.05	
	Application 36m boom x 6 ($3.81/ha ea.)	22.86	
Total			**81.91**
Fallow + till	Chemicals 2012	59.05	
	Application 36m boom x 6 ($3.81/ha ea.)	22.86	
	Speed tiller operation	35.41	
Total			**117.32**
BM peas	Chemicals 2012	52.08	
	Application 36m boom x 4 ($3.81/ha ea.)	15.24	
	Seed @ 100kg/ha @ $227.46/t*	22.75	
	Fertilizer –none used	0	
	Seeder operation	15.41	
Total			**105.48**
BM peas + till	Chemicals 2012	52.08	
	Application 36m boom x 4 ($3.81/ha ea.)	15.24	
	Seed @ 100kg/ha @ $227.46/t*	22.75	
	Fertilizer –none used	0	
	Seeder operation	15.41	
	Speed tiller operation	35.41	
Total			**140.89**

* Farmer owned seed costs $227.46/t or $22.75/ha (production costs + cleaning + inoculation) Speed tiller $20/ha + tractor at $15.41/ha.

Clearly Brown manuring and long fallow produce no income and have maintenance costs that need to be recovered in later years. Potential returns from either system depend on increased yields in subsequent crops and lower production costs from residual Nitrogen status and reductions of herbicide applications. These systems could be more sustainable long term and may address issues with herbicide resistance.

Trial 2. Comparison between Canola and wheat following brown manure peas at Lockhart.

Aim

To measure the impacts on wheat and canola of brown manure peas. Focus on N usage, moisture conservation, weed control and yield.

Method

In a paddock sown to peas and sprayed out as brown manure in 2011 Steve Day and Mark Day sowed three alternate plots of Canola and wheat 36m wide by 400m long.

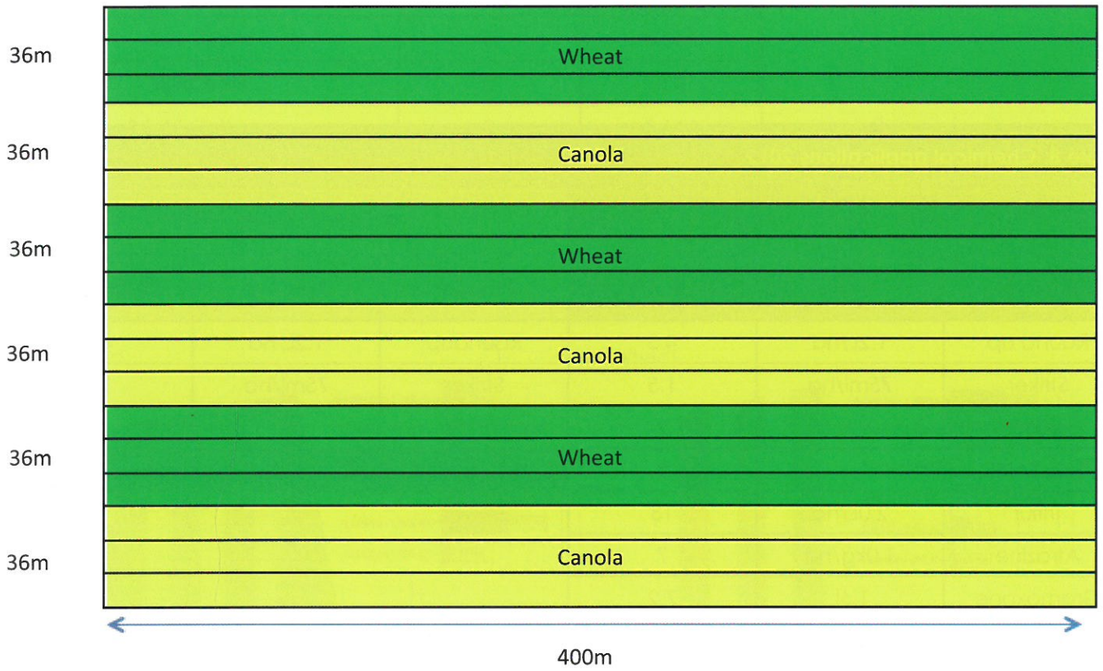


Figure 2: Lockhart trial plan double break vs single break following brown manure peas.

Table 7. Pre-sowing soil testing results.

Depth (cm)	Moisture Content (mm/mm)	pH (1:5 water)	EC (uS/cm)	Available N (Kg/ha)	Available P (Colwell mg/Kg)	% Organic C
0 - 10	29	6.74	81.2	14.44	23.38	1.42
10 - 40	46	8.79	172	46.11	0.21	0.53
40 - 70	47	9.25	192.5	40	0.42	0.30
70 - 100	46	9.39	219	26.9	0.00	0.11

Calculated total N to one metre was 127kg/ha. Colwell P was low at 24mg/kg. Moisture was recorded at 168mm/mm which is a satisfactory level of subsoil moisture.

Table 8. Chemical applications 2012.

Canola Sequence Trial			Wheat Sequence Trial		
Product	**Rate/ha**	**$ Cost/ha**	**Product**	**Rate/ha**	**$ Cost/ha**
Round up	1.2L/ha	4.5	Roundup	1.2L/ha	4.5
Striker	75ml/ha	1.5	Striker	75ml/ha	1.5
Li700	-	2	Li700	-	2
Sub-Total		**8**	**Grand Total**		**8**
Triflur	2.0L/ha	13			
Atrazine	1.0kg/ha	7			
Gramoxone	1.6L	7.2			
Sub-Total		**27.2**			
Clethodim	500ml/ha	7.5			
Atrazine	1.0kg/ha	7			
Uptake oil	0.5l/100L	2			
Sub-Total		**16.5**			
Grand Total		**51.7**			

Results

The wheat following brown manure contained higher numbers of the listed weeds. However numbers were not critically high in the wheat treatment. Paddock results for the next two seasons will be collected to determine the ongoing variation in costs and management between the two treatments.

Establishment – Canola 31 plants/m² Wheat 96.1 plants/m²

Table 9. Weed count results.

Weeds present November 2012	Averages /m²	
	Canola	Wheat
Annual rye grass	0.033	0.2
Milk thistle	0	0.066
Wild oats	0	0.2
Prickly lettuce	0	0.166
Wild mustard	0	0.033

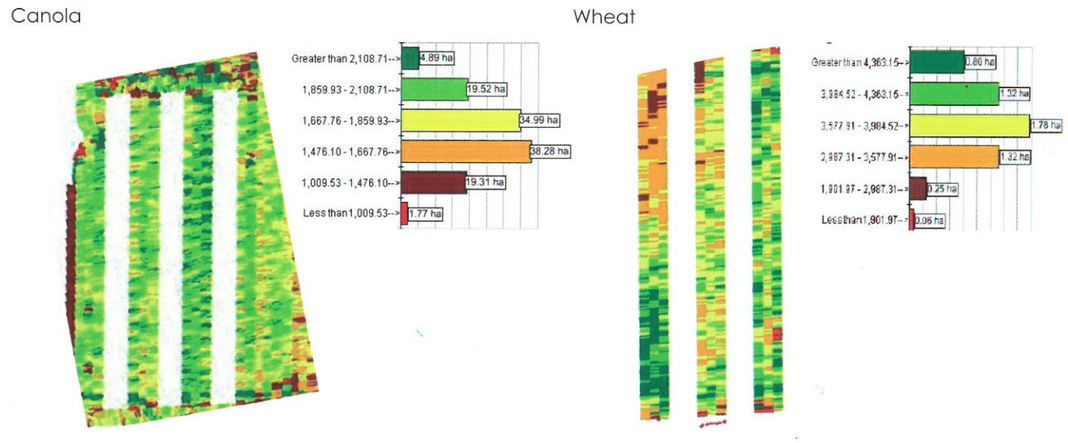


Figure 3: Yield monitor maps, Canola vs Wheat.

Canola yields were calculated from the yield monitor at an average of 1.8t/ha in the trial area. Wheat averaged 4t/ha, test weight of 78kg/HL, protein 11%, screenings 3.3% and moisture of 9.5% in the trial area. Soil analyses in 2013 will determine residual N and moisture levels in the treatments down to 1.8m.

This trial is a three year study focusing on the long term impacts on profitability, weed control, soil moisture, disease and yield of a brown manure system using field peas. We wish to determine if the actual benefits of a brown manure pea crop can improve yields and reduce costs sufficiently enough to compensate for one year of negative income. We will determine if there are any additional benefits from following brown manure with canola as compared to wheat.

Trial 3. The impact on dry matter and grain production of pulses sown early, mid and late.

Aim
To measure the variation in dry matter production, nitrogen fixation, moisture consevation and grain yield as a result of sowing date, legume species and variety.

Method
Four legume species - three field peas, one narrow leaf lupin, one albus lupins and one vetch were selected for sowing at three separate dates replicated three times. Brown manuring was carried out by splitting ranges. Selected varieties were;

Table 9. Trial varieties.

Field peas	Narrow leaf lupins	Albus lupins	Vetch
Morgan	Mandelup	Rosetta	Morava
Percy			

Table 10. Each variety was sown on three separate dates.

Time of sowing 1 (TOS 1)	Time of sowing 2 (TOS 2)	Time of sowing 3 (TOS 3)
20 April 2012	9 May 2012	20 June 2012

Table 11. Treatment list.

Treatment	Grain	Treatment	Brown Manure
1	Hayman_TOS1	19	Hayman_TOS1
2	Morgan_TOS1	20	Morgan_TOS1
3	Morava_TOS1	21	Morava_TOS1
4	Percy_TOS1	22	Percy_TOS1
5	Rosetta_TOS1	23	Rosetta_TOS1
6	Mandelup_TOS1	24	Mandelup_TOS1
7	Hayman_TOS2	25	Hayman_TOS2
8	Morgan_TOS2	26	Morgan_TOS2
9	Morava_TOS2	27	Morava_TOS2
10	Percy_TOS2	28	Percy_TOS2
11	Rosetta_TOS2	29	Rosetta_TOS2
12	Mandelup_TOS2	30	Mandelup_TOS2
13	Hayman_TOS3	31	Hayman_TOS3
14	Morgan_TOS3	32	Morgan_TOS3
15	Morava_TOS3	33	Morava_TOS3
16	Percy_TOS3	34	Percy_TOS3
17	Rosetta_TOS3	35	Rosetta_TOS3
18	Mandelup_TOS3	36	Mandelup_TOS3

Photo 8: Morgan peas 25/7/12
TOS 1 – 20/4/12

Photo 9: Morgan peas 25/7/12
TOS 2 – 9/5/12

Photo 10: Morgan peas 25/7/12
TOS 3 – 20/6/12

Photo 11: Morgan peas
TOS 1 – 17/10/12

Photo 12: Morgan peas
TOS 2 – 17/10/12

Photo 13: Morgan peas
TOS 3 – 17/10/12

Results

The aim of the trial was to investigate variation in dry matter production, the impacts on N mineralisation, weeds and moisture conservation of grain production of sowing date across a range of legumes commonly used in the industry. To achieve this the plots were split 50:50 brown manure:grain. Maturity dry matter cuts were collected and machine harvest was conducted on the 30th November, 2012.

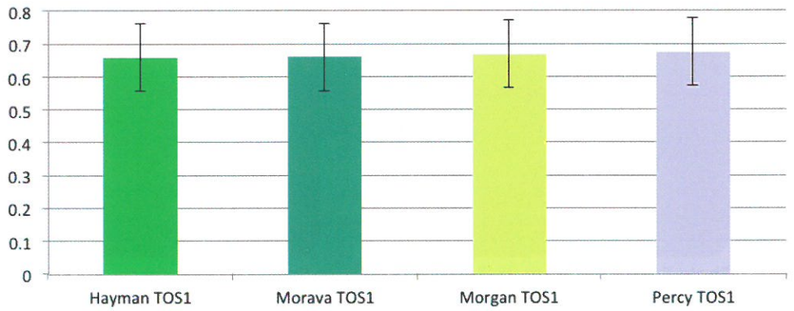


Figure 5. TOS 1 NDVI measurements 25/7/12. Peas and vetch. No significant difference.

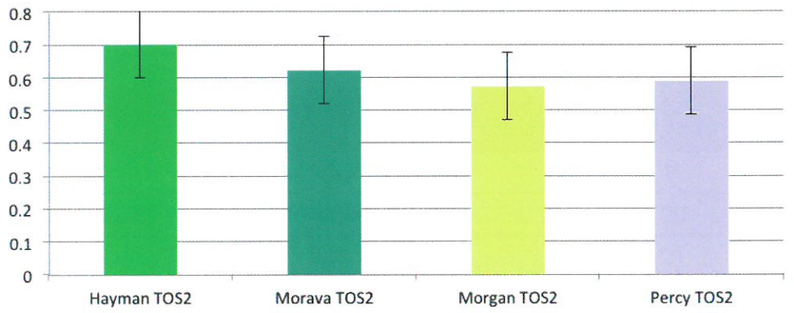


Figure 6. TOS 2 NDVI measurements 25/7/12. No significant difference.

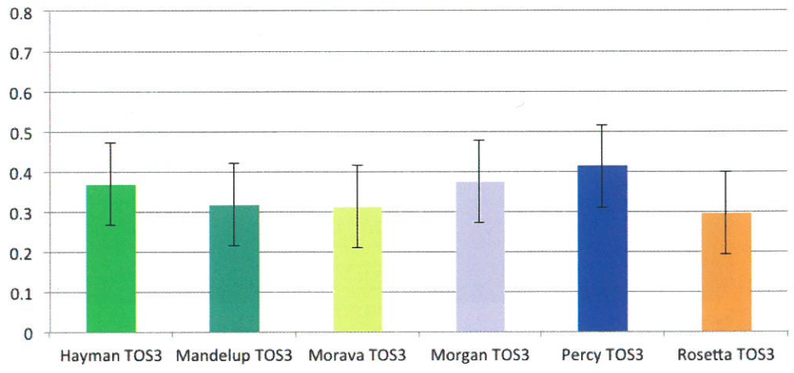


Figure 7. TOS 3 NDVI measurements 25/7/12. No significant difference.

Table 12. Species-Variety x Time of Sowing Interactions.

Treatment/ Species	TOS	DM	%N	Shoot Nitrogen kg/N/ha	%N fix	Shoot Nitrogen Fix kg/N/ ha	Shoot Nitrogen Fix kg/N/t/ DM	TN Fix kg/N/ ha
FP-Hayman	1	5.2	2.11	138	77	102	16	151
FP-Hayman	2	7.44	2.03	151	78	118	16	173
FP-Hayman	3	6.85	1.62	111	76	84	12	124
FP-Morgan	1	6.74	2.7	181	63	112	17	165
FP-Morgan	2	6.25	2.25	141	78	111	18	162
FP-Morgan	3	4.37	2.07	91	76	70	16	102
FP-Percy	1	7.76	2.86	221	84	187	24	274
FP-Percy	2	6.73	2.47	167	72	123	18	180
FP-Percy	3	5.36	2.42	128	73	93	18	137
NLLupin-Mandelup	2	5.85	2.62	154	60	93	16	123
NLLupin-Mandelup	3	2.21	2.63	59	64	42	17	56
Vetch-Morava	1	6.42	2.86	180	78	143	22	211
Vetch-Morava	2	5.46	2.87	157	71	111	20	164
Vetch-Morava	3	6.59	2.95	194	71	138	21	205
p-value (<0.05)	**0.01**	**NS**	**0.023**	**NS**	**0.04**	**NS**	**0.045**	
lsd		**1.89**	**-**	**55**	**-**	**45**	**-**	**65**

No significant differences in N fixation efficiencies between species or TOS. Significant advantage in total N fixed for Percy TOS 1 over all others except Morava TOS 1. With reasonable resistance to bacterial blight and good early sown dry matter Percy or Morava would be favoured for early sowing of brown manure crops. The aim of the trial was to determine if an earlier sowing date would increase DM production and thus N fixation. The data from this site in 2012 supports the theory that an early sowing date will increase DM and total N fixation in Percy and Morava.

A note of caution for early sowing dates is the potential impacts of bacterial blight and downy mildew. Specific management strategies, such as variety resistance and traffic exclusion, to avoid plant injury may prevent bacterial blight infections.

Morava vetch performed well at TOS 3 and was significantly better than Hayman, Morgan, Percy and Mandelup.

Table 13. Species-Variety comparison.

Treatment	TOS	DM	%N	Shoot Nitrogen kgNha	%N fix	Shoot Nitrogen Fix kg/N/ha	Shoot Nitrogen Fix kg/N/t/ DM	TN Fix kgNha
FP-Hayman	Combined	6.5	1.92	133	77	101	15	149[b]
FP-Morgan	Combined	5.79	2.34	138	73	97	17	143[b]
FP-Percy	Combined	6.62	2.58	172	76	134	20	197[a]
Mandelup	Combined	4.16	2.72	119	62	77	17	104[b]
Vetch-Morava	Combined	6.16	2.89	177	74	131	21	193[a]
p-value (<0.05)		**<.001**	**<.001**	**0.003**	**0.001**	**<.001**	**<.001**	**<.001**
lsd		**1.09**	**0.2**	**32**	**7**	**26**	**2**	**38**

Total N fixation production for Morava and Percy was significantly higher than Morgan, Hayman and Mandelup.

Table 14. Time of sowing comparison.

Treatment	TOS	DM	%N	Shoot Nitrogen kgNha	%N fix	SN Fix kgNha	SN Fix kgNtDM	TN Fix kgNha
Combined	1	6.11	2.69	173	73	128	20	187[a]
Combined	2	6.35	2.45	154	72	111	17	161[ab]
Combined	3	5.08	2.34	117	72	85	17	125[c]
p-value (<0.05)		**0.84**	**<.001**	**<.001**	**NS**	**<.001**	**0.01**	**<.001**
lsd		**0.01**	**0.15**	**25**	**-**	**20**	**2**	**29**

TOS 3 was significantly lower than TOS 1 and TOS 2 for DM and therefore total N fixation. There were no significant differences in N fixation efficiency between TOS.

Table 15. Grain yields bulk all times of sowing.

Crop	Hayman	Mandelup	Morava	Morgan	Percy	Rosetta	P value	lsd (P<0.05)
Grain Yield	1.53[b]	1.23[c]	1.53[b]	1.79[a]	2.11[a]	1.81[a]	**<0.001**	**0.3169**

Table 16. Grain yield all species x time of sowing.

TOS	1	2	3	P value	lsd (P<0.05)
Grain Yield	1.31[b]	1.95[a]	1.74[a]	<0.001	0.2241

Values with the same letter are not significantly different.

Table 17. Grain yield species-variety comparison.

	TOS				
Crop	**1**	**2**	**3**	**P value**	**lsd (P<0.05)**
Hayman	1.03[c]	1.44[b]	2.12[a]	0.002	0.5488
Mandelup	0.87[b]	1.73[b]	1.08[c]		
Morava	1.59[b]	1.57b	1.44[b]		
Morgan	1.43[b]	1.95[a]	2.00[a]		
Percy	1.48[b]	2.44[a]	2.39[a]		
Rosetta	1.46[b]	2.26[a]	1.39[b]		

Values with the same letter are not significantly different.

Discussion

Converse to dry matter production, the early time of sowing has had a significant negative impact on grain yield. Hayman, Morava, Morgan, Percy and Rosetta were all significantly lower in TOS 1 when compared to TOS 2 and TOS 3. (NB Mandelup data not used) There were no significant differences between the pea varieties in TOS 2 and TOS 3 except Hayman that increased significantly in TOS 3. Mandelup and Rosetta both had negative responses to a later sowing date for grain yield at this site.

N content of grain samples have yet to be tested and cannot be reported at time of writing. Soil samples pre-sowing in 2013 will determine the actual N and moisture levels for all the treatments.