Brown manuring pulses on acidic soils in southern NSW – is it worth it?

Eric Armstrong[1], Gerard O'Connor[1], Luke Gaynor[1], **Sarah Ellis[1]** and Neil Coombes[1]

[1] NSW Department of Primary Industries, Wagga Wagga Agricultural Institute
PMB Pine Gully Road, Wagga Wagga NSW 2650, sarah.ellis@dpi.nsw.gov.au

Abstract
Field pea and vetch are the two most popular brown manure choices in southern NSW, and their cultivation is largely dependent on the need to control herbicide resistance weeds. Brown manuring also brings other potential benefits such as the addition of soil nitrogen, and more ground cover over the summer period.

NSW DPI Pulse team established a series of experiments at Wagga Wagga in southern NSW to investigate the effects of pulse crops on the farming system if harvested for grain or brown manured. Three separate cropping sequences have been established to date, the first commencing in 2012, then 2013 and 2014. A range of legume crops were sown in year one (6 in 2012 and 7 in 2013) at three sowing times and were either brown manured at the stage of black oat anthesis or the crop was taken through to grain harvest. These were followed with two consecutive wheat crops in 2013 and 2014. There are four key messages from this work. Firstly, southern NSW growers will maximise their rotational returns by taking pulse crops through to harvest and selling the grain. Secondly, most pulse crops are likely to provide flow-on benefits to the following wheat crops provided they are well managed. Thirdly, growers should choose the pulse that best fits their farming system – the one easiest to grow and market. Finally, weeds are the major driver for brown manuring in southern NSW.

Key words
Herbicide resistance, legumes, rotation, farming system

Introduction
Pulse crops are a valuable component of farming systems in southern NSW with considerable potential to expand because of their well-documented benefits to following crops such as improved weed control, increased soil nitrogen, reduced cereal diseases and greater available stored soil water (Armstrong & Holding 2015).

Approximately 110,000 hectares of pulses (field pea, lupin, chickpea, faba bean and lentil) were sown in southern NSW in 2014 (*Pulse Australia Crop Forecast*, 9 February 2015), representing about 4% of total land cropped. Anecdotal evidence points to a further 20,000 or more hectares of vetch within the same system grown for brown manuring, hay or seed. Growers intentions to sow pulses either for grain or brown manure are generally known well in advance of sowing and very few grain crops end up brown manured as a last minute decision. The decision to follow this strategy is driven largely by the presence of weeds, particularly herbicide resistant grass weeds. Field pea and vetch are the two most popular brown manure choices. Morgan is the preferred field pea variety for brown manuring because it is taller, bulkier and more competitive with weeds. Morava and Blanchefleur are the most common vetch varieties but growers are now moving to the earlier, higher yielding variety Volga. Brown manuring also brings further benefits of addition of soil nitrogen from N_2-fixation, extra soil moisture storage as a result of the earlier "fallow" and a more protective mulch cover over the summer period (Gaynor *et al*. 2012).

These substantial benefits do come at a price – no income that year. The obvious questions are how does this strategy compare to growing a pulse for grain alone, and can productivity be recouped in the following two wheat crops? This paper attempts to address this question using three seasons of experiments conducted at Wagga Wagga in southern NSW.

Methods
Experiments were conducted at Wagga Wagga on acidic Red Chromosols, pH ($CaCl_2$) 4.5-5.0, typical for southern NSW. In 2012 a brown manure trial compared the time of sowing (TOS) of 6 legume crops either brown manured or harvested for grain. Brown manuring was carried out using two applications of non-

selective herbicides (double knock) at anthesis or early milky dough of black oats (Avena sp.). Although relatively early compared to the development of the pulse crops this timing was chosen due to the recent rise in herbicide resistant black oats requiring specialist management in the region. A wheat crop followed in 2013 and 2014. The brown manure trial was repeated in 2013 and compared 3 TOS of 7 legumes and a non-legume (wheat) crop that were either brown manured or harvested for grain. Brown manuring was again carried out at anthesis of black oats stage. In 2014 wheat (cv. Lancer) was sown across both trials to measure residual effects of pulse treatments on wheat yield and protein. Both years experienced environmental constraints of frosting and a dry finish, partially restricting full yield expression of some or all treatments. Normal agronomic practice was followed for seeding, weed and pest control and harvest. The wheat was sown with 80 kg/ha of MAP fertiliser (NPKS 10:21.9:0:1.5). No additional N was applied to the wheat crop.

Results and discussion

The Wagga Wagga climate is temperate, with long-term average annual rainfall of 530mm, and 328mm growing season rainfall (GSR) April – October. During the 2012 season there was 194mm during March, but this was followed by a drier than average GSR (160mm). Pulse crops grew well on the stored moisture with low pressure from fungal disease in the dry atmospheric conditions. 2013 was a below average year with 128mm summer rainfall, 251mm GSR and 390mm total rainfall, and was exacerbated by frosts during October. 2014 was similar with 458 mm annual rainfall and 278mm GSR and again was impacted by a dry, frost prevalent spring.

Brown manure biomass and grain yields from 2012 and 2013

In 2012 there were significant effects of TOS and variety on biomass at the time of brown manuring (Figure 1) and on final grain yield (Table 1). Greatest biomass was achieved by sowing Morava vetch early in mid-April. For later sowings in May and June field peas were equal to or more productive than vetch. Lupins did not perform well but had suffered from pest grazing (wild hares) at emergence, from which they were unable to fully recover. Grain yields up to 3 t/ha were achieved by PBA Percy field peas. Morava vetch had consistent grain yields just below 2 t/ha for each TOS despite having significant differences in anthesis biomass.

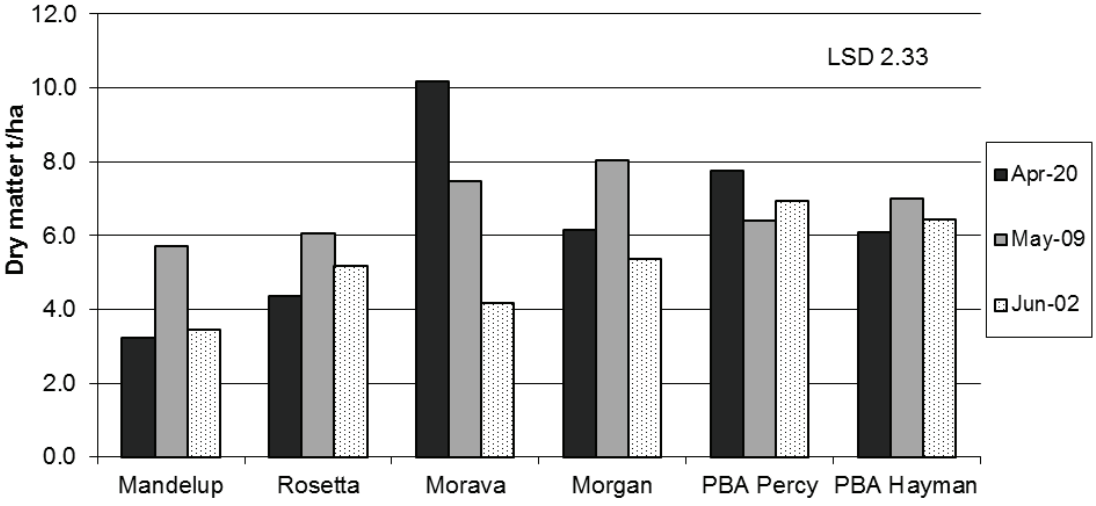

Figure 1. Above ground biomass (t/ha) of brown manures for each TOS at the timing of black oat anthesis in 2012.

Table 1. Grain yields (t/ha) of crops for brown manure at each TOS in 2012 and 2013.

		2012			2013		
		Apr 20	May 9	Jun 2	Apr 12	May 27	Jun 11
Faba bean	Fiord				2.41	2.26	1.77
Lupin	Mandelup	1.12	2.14	1.33	1.59	1.40	1.39
	Rosetta	1.64	2.79	1.71	1.42	1.60	1.54
Vetch	Morava	1.96	1.94	1.78	0.86	1.17	1.49
Field pea	Morgan	1.77	2.40	2.47	1.80	1.59	1.30
	PBA Percy	1.83	3.01	2.95	1.99	2.08	2.02
	PBA Hayman	1.27	1.77	2.27	0.64	0.57	0.62
Wheat	Lincoln				3.14	2.71	2.66
LSD			0.71			0.30	

In contrast, there were no TOS effects on anthesis biomass in 2013, and only small variety effects (Figure 2). There were no differences in anthesis biomass between the 3 field pea varieties and Morava vetch, and Rosetta lupin, Mandelup lupin and Fiord faba bean were only significantly less than Morgan field pea. The highest pulse grain yields were from faba beans sown early. Field pea grain yields again showed very little response to TOS. No treatment effects were evident in wheat grain yields (data not shown) following the 2012 treatments, but this could have been masked by frost damage. Average brown manure biomass in 2013 was substantially less than the previous season due to lower available moisture and some plant stresses associated with frost and diseases.

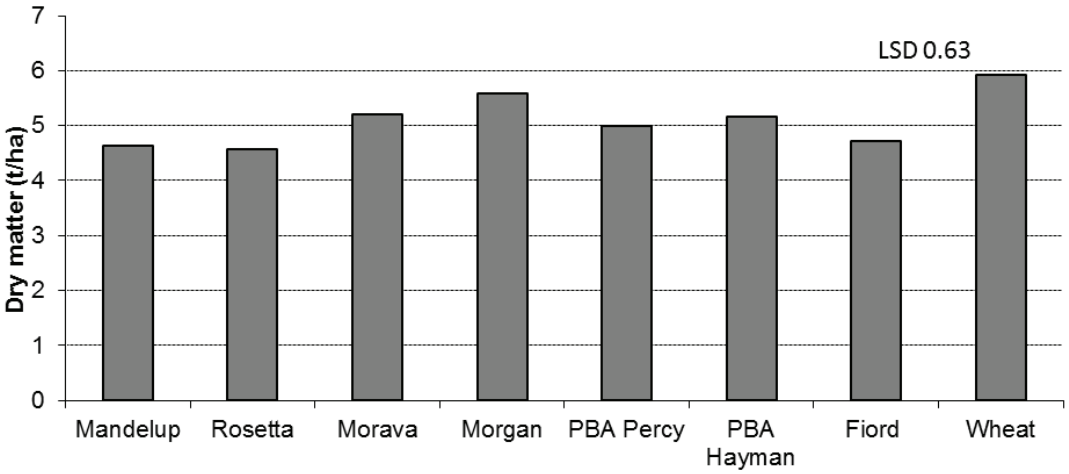

Figure 2. Above ground biomass (t/ha) of brown manure crops averaged across TOS for varieties at anthesis of black oats in 2013.

Wheat 2014 after brown manure 2013

The wheat (cv. Lancer) sown after wheat harvested for grain in 2013 yielded 2.8 t/ha in 2014 (Table 2). This was lower yielding than wheat after all of the pulses that were harvested for grain in 2013 (average 3.3 t/ha). There were no significant differences between wheat yields after any of the brown manure treatments and TOS in 2013, including the cereal (average 3.4 t/ha). However the dry spring in 2014 is likely to have restricted the yield potential and minimised the expression of any treatment effects.

The main rotation effect was seen in wheat grain protein. Grain protein of wheat after wheat rotation was well below 10% and this would generally incur a substantial marketing issue with price affected due to low protein percentage. Manuring the previous crop led to a significant increase in grain protein of 1.0 to 1.5% compared to that harvested for grain, but this is unlikely to negate the opportunity cost of manuring the previous crop for yield and protein gains alone.

Table 2. 2014 wheat grain yield (t/ha) & protein (%) after 2013 brown manure & harvested grain crops

Crop	**Variety**	**2013**	**Wheat 2014**		**Protein**		**Grade**	
		Pulse	Grain	Manure	Grain	Manure	Grain	Manure
		t/ha	t/ha	t/ha	%	%		
Faba bean	Fiord	2.15	3.35	3.46	10.3	11.7	ASW	H2
Lupin	Mandelup	1.46	3.34	3.30	10.9	12.5	APW	H2
	Rosetta	1.52	3.30	3.46	11.1	12.6	APW	H2
Vetch	Morava	1.17	3.35	3.34	11.2	12.5	APW	H2
Field pea	Morgan	1.56	3.33	3.46	10.8	11.9	APW	H2
	PBA Percy	2.03	3.25	3.45	11.2	12.2	APW	H2
	PBA Hayman	0.61	3.38	3.37	11.5	12.0	APW	H2
Wheat	Lincoln	2.84	2.89	3.31	8.7	9.6	ASW	ASW
LSD:		0.18	0.25		0.5			

Wheat 2014 after wheat 2013 and brown manure 2012

Two years after brown manuring there were still benefits evident in the system. Wheat sown 2 years after the brown manuring trial averaged 3.5 t/ha (Table 3). There were no significant differences between crops brown manured or harvested for grain, and only a small decrease in yield for wheat grown 2 years

after Mandelup lupins compared to Morava vetch, Hayman and Percy field peas. However there remained treatment effects with more protein (about 0.5%) in the wheat following pulse crops that had been manured (12.6%) instead of harvested for grain (12.0%). There were also differences between species (Table 3), with most increase in wheat grain protein following Morava vetch and Percy field pea, and the least protein percentage following the lupin crops. This may reflect the biomass of the preceding legumes.

Table 3. 2014 wheat yield and protein after 2013 wheat after 2012 brown manure trial

2012 Crop	Variety	2014 wheat grain yield t/ha	Protein %
Lupin	Rosetta	3.46	11.7
	Mandelup	3.35	11.9
Field pea	Morgan	3.48	12.3
	Hayman	3.68	12.4
	Percy	3.64	12.7
Vetch	Morava	3.65	12.7
	LSD	0.22	0.4

Conclusions

Growing any of the pulse crops adapted to southern NSW has significant advantages for subsequent wheat yields in the first and second year compared to growing wheat on wheat. Inclusion of lupin, field pea, faba bean or vetch phases, either harvested for grain or brown manured, gave a significant boost to subsequent wheat production in these southern NSW experiments. While there were no significant differences in wheat yields following legumes either harvested for grain or brown manured, wheat grain protein content did significantly improve by 1.0 to 1.5% after brown manuring. This small but significant increase in wheat protein is still unlikely to compensate for total loss of returns from brown manuring the previous year. This suggests that in the absence of herbicide resistant weeds, growers will maximise their rotation gross margin by taking pulse crops through to harvest and selling the grain. Other studies and technical guides have shown brown manures work best when weed resistance is the major driver, and residual nitrogen and moisture conservation important but secondary considerations (Armstrong, 2015; Gaynor et al., 2012; McGillion and Storrie, 2006).

There are four key messages from this work. Firstly, southern NSW growers will maximise their rotational gross margin by taking pulse crops through to harvest and selling the grain. Secondly, most pulse crops are likely to have similar flow-on benefits to the following wheat crops provided they are well managed. Thirdly, growers should choose the pulse that best fits their farming system – the one easiest to grow and market. Finally, brown manuring in southern NSW is most effective when herbicide-resistant weeds are the major driver.

Acknowledgments

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