Optimising the production potential of vetch on poor Mallee sands

Brian Dzoma[1], Nigel Wilhelm[1] and Peter Telfer[2]
[1]SARDI Waite, [2]SARDI Turretfield

RESEARCH

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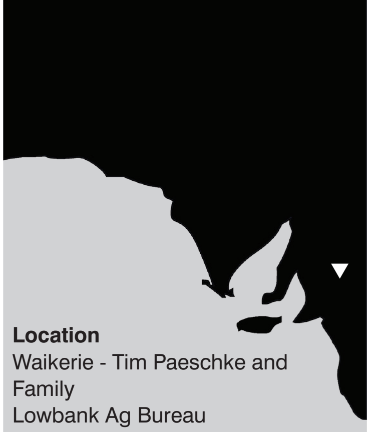

Location
Waikerie - Tim Paeschke and Family
Lowbank Ag Bureau
Rainfall
Av. Annual: 288 mm
Av. GSR: 163 mm
2017 Total: 211 mm
2017 GSR: 96 mm
Paddock History
2016: Wheat
2015: Wheat
2014: Clearfield barley
Soil Type
Alkaline sand (sandhills)
Plot Size
25 m x 1.8 m x 4 reps
Yield Limiting Factors
Moisture

Key messages

- **Vetch productivity on poor sandhills can be improved when phosphorus is not limiting.**
- **High soil N levels are detrimental to vetch root and shoot biomass, nodules and grain production.**
- **Placing phosphorus deeper at sowing is beneficial for improved root and shoot biomass and grain yield.**

Why do the trial?

Legumes have an important role in modern farming systems, greater than their traditional nitrogen fixation and 'disease break' properties. Australian farmers have adopted vetch as a pulse rotation crop in regions where low rainfall is a major environmental stress. The versatility of vetch as a valuable legume is gaining ground in low-medium rainfall mixed farming systems. In 2016, approximately 32,000 ha of vetch was grown in South Australia, with 32% of that area being grown in the SA Mallee (Rural Solutions, 2017).

Traditionally, vetches were sown as mixes for hay, or grown for grazing only. Nowadays vetches are being used for disease and weed break crops in the rotation, grain for stockfeed, hay and silage production, green and brown manure and green and dry grazing. In the SA Mallee, vetch crops on sands, particularly sandhills, struggle to grow and reach their full production potential. The main aim of the trial reported here was to identify if nutrition was a major factor in the poor productivity of vetch on Mallee sands, and if so, which specific nutrients are responsible.

How was it done?

Nine different broadleaved crop options were compared over three seasons (2015-2017) on four soil types commonly found in the northern Mallee region. Trials were located at Waikerie and Loxton and at each site trials were located on two contrasting soil types. A brief description of each of the four soil types is provided below:

- Loxton Flat: Red loam located in a swale
- Loxton Sand: Deep yellow sand located on the top of an east-west dune
- Waikerie Flat: Heavy red-grey soil with limestone from 20-30 cm below the surface
- Waikerie Sand: Red sandy loam located mid-slope

How was it done?

A replicated trial was established at Waikerie on a sandhill with poor-marginal soil fertility (Table 1) on 10 May 2017. Both N and P were low in the top 10 cm and at depth.

Rasina vetch seed was sown in 25 m x 1.8 m plots at 35 kg/ha with varying nutrient packages (Table 2). The trial had two components, with the main trial being set up as a nutrient omission trial starting with a treatment that had a comprehensive nutrient package (N, P, K, S, Zn, Mn, Cu and B), and eliminating one nutrient at a time. The control had no nutrients added to it. The second component of the trial had three treatments which investigated the effect of nutrient placement (shallow vs deep) on vetch establishment, dry matter and seed production.

Table 1. Background soil fertility.

	mg/kg							
	NO_3 + NH_4 N	Colwell P	Colwell K	KCl Sulphur	Boron	DTPA		
	N	P	K	S	B	Zn	Mn	Cu
0-10 cm	2	21	175	4.1	0.3	0.8	0.9	0.1
10-60 cm	2.3	5	132	4.1	0.5	0.2	0.6	0.2

Table 2. Treatments applied at Waikerie in 2017.

Treatment		kg nutrient per hectare							
		N	P	K	S	Zn	Mn	Cu	B
Component 1 (Omission trial)	Complete	50	20	45	20	2	3	1	1
	Minus B	50	20	45	20	2	3	1	*
	Minus Cu	50	20	45	20	2	3	*	1
	Minus Mn	50	20	45	20	2	*	1	1
	Minus Zn	50	20	45	20	*	3	1	1
	Minus S	50	20	45	*	2	3	1	1
	Minus K	50	20	*	20	2	3	1	1
	Minus P	50	*	45	20	2	3	1	1
	Minus N	*	20	45	20	2	3	1	1
	Control	*	*	*	*	*	*	*	*
Component 2 (P placement)	Deep P + Zn	*	10	*	20	2	*	*	*
	Shallow P + Zn	*	10	*	20	2	*	*	*
	Shallow P	*	10	*	20	*	*	*	*

(Nitrogen - N, phosphorous - P, potassium - K, sulphur - S, zinc - Zn, manganese - Mn, copper - Cu, boron - B). Zn, Mn and Cu were applied as sulphates and boron as boric acid.

Crop establishment was estimated on 31 May; sampling for nodulation and root diseases on 4 August, and late dry matter (DM) cuts at mid flowering-early podding on 19 September. On 24 August, Verdict was applied @ 75 ml/ha plus uptake oil for grass control and Lemat @ 200 ml/ha for aphid control at a water rate of 100 L/ha. The trial was harvested on 20 November 2017 to determine vetch grain yield.

What happened?

During the early stages of crop emergence, any treatment that had N did not look as good as the treatments without N. However, all treatments had similar plant numbers to the control for the nutrient omission trial. The site mean was 57 plants/m^2. Shallow P however resulted in a 22 and 27% reduction in plant numbers for the 'shallow P + Zn' and 'shallow P' treatments respectively.

Prior to flowering, some of the vetch plots were showing signs of stunted growth so all plots were sampled (4 samples/plot) for root diseases, root dry matter and nodulation scoring. After scoring, roots from plants without any N added had the best score for root health and any treatment that had N had the worst root health score (Table 3). The site mean root health score was 2.7, which indicates a heavy disease burden on the scale of 1-5 (0 = good and 5 = bad). The site mean for *Pratylenchus neglectus* nematodes was 7760 nematodes/g soil, which is classified as high risk for crops during the growing season (Garrard, 2018). Shallow P (14310) and Minus N (14230) were the only treatments that had significantly higher ($P<0.001$) nematodes per gram of soil, and all the treatments that received N had significantly ($P<0.001$) less nematodes than the control. *Rhizoctonia solani* AG8 was also detected at the site (mean 110 pgDNA/g sample), but in low - moderate levels for an in-crop assessment. The levels ranged from 0 to 470 pgDNA/g sample which suggests there was some impact on the plants but highly unlikely to be the primary cause of root damage.

For vetch on light soils, 20 nodules per plant at 8 weeks post sowing is considered satisfactory (GRDC, 2014). Treatments without any N (minus N, Deep P + zinc, shallow P + zinc) had good nodule numbers over 20, however any treatment that had N at sowing had very poor nodule numbers; less than 10 nodules per plant. For root dry weight, shallow P + Zn, minus N, shallow P and deep P + Zn, produced higher root dry weight than the control, although no treatment performed worse than the control. In terms of final grain yield, no treatment performed better than the control sown with no added nutrition, however, minus S, minus Cu, minus P and minus Zn, had significantly lower grain yield than the control.

What does this mean?

The production of vetch in low-medium rainfall mixed farming systems is becoming more common because of its versatility. Depending on end use, vetch can return 50-60 kg/ha of nitrogen to the soil after production of grain, and 65-100 kg/ha after cutting for hay (Matic *et al*. 2006); confirming its importance in improving soil N fertility. Results from this trial have demonstrated that high soil N levels are detrimental to vetch root and shoot biomass, nodules and grain production. Removing the N from the 'complete' treatment resulted in a 47% increase in shoot dry matter (t/ha) and a 117% increase in grain yield (kg/ha). Sowing vetch with N is not a common practice, but these results suggest that vetch sown in a paddock with high residual N may be at risk to a biomass and yield penalty.

Table 3. Crop establishment, root diseases, nodule counts, root dry weight, late DM and grain yield of vetch sown on an alkaline Mallee sand in 2017.

Treatment	**Crop establishment (plants/m²)**	**Root health score (0=good 5 =bad)**	***Pratylenchus neglectus* nematodes /g soil**	***R. solani* AG8 pgDNA/g Sample**	**Nodules/ plant**	**Root dry wt (mg/ plant)**	**Dry matter (t/ha)**	**Grain yield (kg/ ha)**
Minus N	64	1.7	14230	0	21.9	131	2.2	274
Minus P	61	3.2	5560	160	3.5	73	1.1	155
Deep P + Zn	61	2.0	10340	80	23.2	119	2.2	323
Complete	60	2.8	6080	120	4.5	61	1.5	126
Minus S	59	3.4	5560	120	5.9	56	1.6	159
Control	59	2.5	9370	120	13.9	94	1.5	245
Minus Zn	59	3.1	4000	0	5.1	40	1.5	123
Minus Mn	58	3.4	4920	0	5.2	49	1.5	169
Minus Boron	58	3.1	4100	330	5.0	41	1.7	171
Minus Cu	57	3.1	5230	0	6.9	52	1.8	159
Minus K	53	2.5	4470	50	6.4	45	1.6	166
Shallow P + Zn	46	2.1	12700	0	21.0	127	2.1	287
Shallow P	43	2.4	14310	470	18.6	143	1.4	210
Grand mean	**57**	**2.7**	**7760**	**110**	**10.8**	**96**	**1.7**	**198**
LSD (P=0.05)	*9*	*0.4*	*3500*	*450*	*3.8*	*26*	*0.4*	*84*

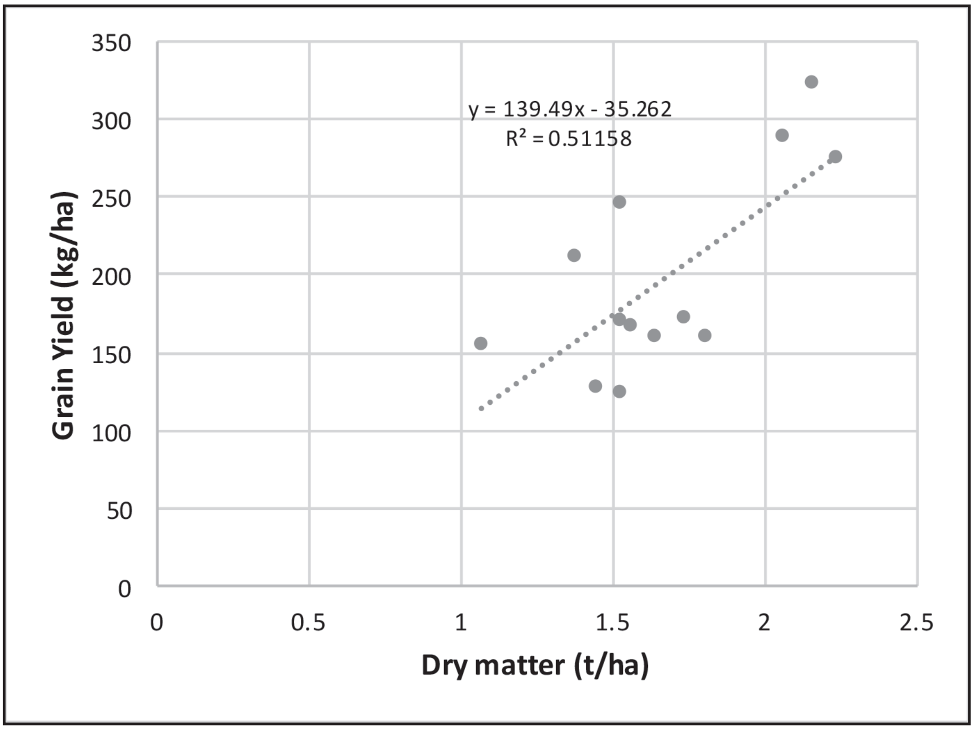

Figure 1. Relationship between final grain yield (kg/ha) and late dry matter (t/ha).

This trial has also shown that phosphorus is a critical macronutrient in vetch production, and that the gains in productivity are higher when P is placed deeper away from the seed at sowing. There was a 27% penalty in dry matter when the vetch was sown with no P, and a 47% increase in dry matter by adding P at sowing, 8 cm below the seed. P was marginal in the top 0-10 cm but was limiting in the 10-60 cm subsoil, hence the positive response in root dry weight, late dry matter and grain yield. Potassium, sulphur, zinc, manganese, copper and boron did not significantly change late dry matter and grain yield of the vetch on the sandhill.

Average dry matter yield for Rasina vetch grown in 2006 at a trial site in Kingsford was 4.8 t/ha and 2.5 t/ha in Lameroo (Matic *et al*. 2006), and average grain yield for 2009, 2010 and 2011 was 2.2 t/ha from 4 sites in SA (Nagel *et al*. 2011). Trial site means of 1.7 tDM/ha for late biomass and 198 kg/ha for grain yield reflects the impact of a below average season for the SA northern Mallee. Based on the dry matter produced, higher grain yield was expected, however this was not achieved due to the fact that the crop ran out of moisture during a critical period of grain-filling. Final grain yield was positively correlated to dry matter (Figure 1) i.e. grain yield increased with an increase in dry matter produced. However, the conversion efficiency of the vetch biomass to grain was low, every 1 tonne of dry matter per hectare resulted in only 104 kg grain per hectare.

For the omission trial, the contribution of P, K, S, Zn, Mn, Cu and B was not clear due to the effects of high nitrogen (100 kgN/ha) at sowing. The relative importance of these macro and micro nutrients on vetch still need to be further investigated in replicated field trials where N levels are low or non-toxic. The presence of root diseases should not be disregarded as they also could have affected the response of the crop to the nutirents imposed.

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Mallee Sustainable Farming

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