Legume effects on soil N and wheat grain yield

Sarah Noack and Peter Hooper, Hart Field-Site Group

Key Findings

- Available soil N at the start of 2014 was 20-50 kg N/ha higher for legume treatments compared to wheat.
- Starting soil N did not affect grain yield for nil or additional N applied treatments.
- Differences in grain protein were correlated to starting soil N levels.

Why do the trial?

Currently, growers not utilising a legume within their rotation rely on synthetic nitrogen (N) forms i.e. urea or UAN to supply crop N. This requires a greater workload during the growing season and there is a risk of the N being lost (leaching and volatilisation) or not being taken up by the crop. Compared to legume soil N, which is mineralised for a number of years, synthetic N is a relatively short term supply. The aim of this trial was to grow a legume (field peas) and impose a range of treatments (hay, green manure etc) to create different starting soil N levels prior to sowing with wheat. Thus, keeping disease and moisture levels similar between the treatments. The wheat phase was used to measure the effect of different soil N levels on grain yield and quality, with and without additional fertiliser.

How was it done?

Plot size	5.0 m x 10.0 m	**Fertiliser**	DAP (18:20) + 2% Zn @ 60 kg/ha
Seeding date	15th May 2014		In-season N as specified in Table 1.
Crop variety	Mace wheat @ 180 plants/m^2		

Treatments in 2013

The trial was a randomised complete block design and all plots were sown with Kaspa peas (except one chickpea treatment) and a range of treatments were imposed to create differences in starting soil N in 2014.

1) Pea brown manure – Kaspa (120 kg/ha) sprayed out
2) Pea hay – Kaspa (120 kg/ha) cut and removed from plots
3) High seeding rate – Kaspa (120 kg/ha) plus Hayman (40 kg/ha)
4) Low seeding rate – Kaspa (65 kg/ha)
5) Peas inoculated – Kaspa (120 kg/ha) with 1 handful of peat inocculum down tube
6) Chickpeas – Striker @ 100 kg/ha

On 26th March 2014 all plots were soil cored to 80 cm. Soils were oven dried at 60°C and analysed by CSBP for soil available N (Table 1). Since a number of the legume treatments resulted in similar starting soil N, treatments were split so they received a nil or N application targeting 4.9 t/ha or 6.1 t/ha for 50% and 100% yield probability as determined by Yield Prophet® in early July.

Table 1. Summary of treatment sown in 2013, starting soil N measured in March 2014 and the N fertiliser applied to each treatment.

Crop grown in 2013	Starting soil N 2014	N fertiliser applied in 2014		
		nil	rate 1	rate 2
	kg N/ha	kg N/ha	kg N/ha	kg N/ha
Pea inoculated	92	0	60	
Low seeding rate	92	0		80
High seeding rate	96	0	55	
Pea hay	97	0		80
Pea brown manure	124	0	25	
Chickpea	124	0		50
Wheat	74		50	80

Fertiliser N rate 1 based on a yield target of 4.9 t/ha (or 140 kg N/ha) and N rate 2 was based on a yield target of 6.1 t/ha (or 175 kg N/ha).

Results and discussion

Starting soil N across all legume treatments varied by 30 kg N/ha. All treatments were 20-50 kg N/ha greater compared to the wheat treatment (Table 1). This is consistent with a large number of farmer paddocks sampled in SA from 2002-2014 (Peoples et al. 2014). Their data showed soil N following legumes can be expected to be 25-35 kg N/ha higher than following cereals.

In the current trial, wheat grain yield was not affected by the different starting soil N values (Table 2). This can be attributed to the fact that not all legume N will be immediately available to the subsequent wheat crop. Legume N requires soil microbial processes to breakdown and release N, which takes longer, compared to synthetic N fertiliser sources (eg. urea).

However, application of N to these starting soil N treatments resulted in grain yield differences. Across all N rates the nil N yielded 0.29 t/ha more compared to the plus N treatments. Interestingly, wheat on wheat with 50 kg N/ha applied in season (74 starting N/ha + 50 kg N/ha in season = 124 kg N/ha) yielded the same as 124 kg N/ha soil N, with no N in season.

Table 2. Summary of 2013 crop treatment on 2014 wheat grain yield (t/ha) for nil N and plus N treatments.

Starting soil N kg N/ha	N rate kg N/ha	Grain yield t/ha	N rate kg N/ha	Grain yield t/ha
(pea inoc.) 92	0	4.96	60	4.69
(low seed) 92	0	4.84	80	4.57
(high seed) 96	0	4.80	55	4.68
(pea hay) 97	0	4.93	80	4.48
(pea BM) 124	0	4.90	25	4.39
(chickpea) 124	0	4.83	50	4.70
(wheat) 74			50	4.97
LSD (P≤0.05) Starting soil N		ns		

Treatments with lower starting soil N produced grain with lower protein and vice versa (Figure 1). Between the two N treatments there were also significant differences in protein. All treatments with additional N applied in season averaged 1.3% higher protein compared to the nil (Table 3). This can be attributed to the above average rainfall early in the season setting yield potentials high followed by below average rainfall from August onwards. This lead to a situation of too much N in the plus N treatments for the yield potential, increasing grain protein.

These results are in agreement with Peoples et al. (2014) who did not observe grain yield differences following different starting soil N level (from lupins, wheat and canola). Similarly, wheat protein levels were much higher for treatments with higher starting soil N.

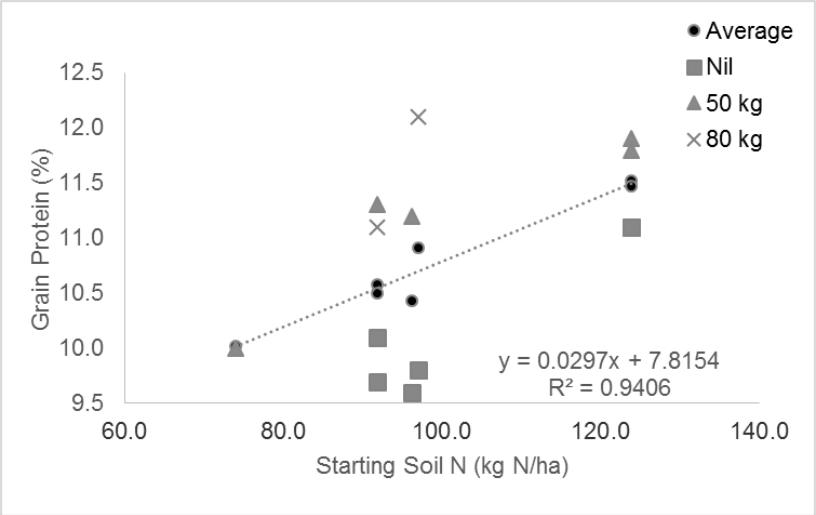

Figure 1. Relationship between starting soil N level (kg N/ha) and final wheat grain protein for the 2013 crop treatments and N rates (nil applied, 50 kg N/ha (45, 55 and 60 kg N/ha grouped), 80 kg N/ha and average N applied).

Table 3. Summary of 2013 crop treatment on 2014 wheat grain protein (%) for nil N and plus N treatments.

Starting soil N kg N/ha	N rate kg N/ha	Protein %	N rate kg N/ha	Protein %
(pea inoc) 92	0	9.7	60	11.3
(low seed) 92	0	10.1	80	11.1
(high seed) 96	0	9.6	55	11.2
(pea hay) 97	0	9.8	80	12.1
(pea BM) 124	0	11.1	25	11.9
(chickpea) 124	0	11.1	50	11.8
(wheat) 74			50	10.0
LSD (P≤0.05)				
Starting soil N		0.7		
N rate applied		0.3		
Starting soil N x N rate		ns		

Comparing legume and synthetic nitrogen sources

Nitrogen removed in wheat grain ranged from 81 – 97 kg N/ha across all treatments (Table 4). The results show 50-60 kg N/ha supplied as urea was required to match an additional 30 kg/ha legume N at the start of the season (Table 4). Therefore at least an extra 30 kg/ha of synthetic N or $30/ha was required in systems with lower starting soil N.

Table 4. Nitrogen removed (kg N/ha) in harvested wheat grain 2014 for all starting soil N treatments.

Starting soil N kg N/ha	N rate	N removal*	N rate	N removal
	kg N/ha			
(pea inoc) 92	0	84	60	93
(low seed) 92	0	86	80	89
(high seed) 96	0	81	55	92
(pea hay) 97	0	84	80	95
(pea BM) 124	0	95	25	91
(chickpea) 124	0	94	50	97
(wheat) 74			50	87

**N removal = grain yield × protein × 1.75*

References

Peoples et al. (2014) Inputs of fixed N by legumes and contributions of legume N to wheat. Hart Field Day Guide, pg 88-92.

Photo: Hart lentil trials at Pinery in 2014.