Nodulation studies with pulses on acidic red sandy soils – Yenda 2014

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Key findings

- Peat and liquid formulations were the most consistent inoculants across all pulses, having the highest nodule scores and equal or highest grain yields compared with the remaining treatments.
- Without inoculation, faba bean and chickpea failed to nodulate indicating host rhizobia were absent at this site. This consequently lowered their grain yields.
- On the other hand, lupin, field pea and lentil effectively nodulated without inoculation, indicating their respective rhizobia had colonised this site.
- Fungicide seed dressing (P-PICKEL T®) did not affect pulse nodulation, but did increase grain yield in chickpea. Further investigation is needed to establish the reasons.

Aim

The aim was to compare different rhizobia inoculant formulations for nodulation, growth and yield of field pea, lupin, faba bean, lentil and chickpea under varying rain-fed and soil moisture conditions on an acidic sandy loam at Yenda in the south-western cropping zone of southern NSW.

Site details

Site	'Hillview' Yenda, RK & JG Eckerman (Paddock 'Wattle Park')
Sowing date	26 May 2014
Soil type	Acidic, red sandy loam, pH_{Ca} (0–10 cm) 4.6 (Table 1)
Design	Randomised complete block design with pulses the main blocks and inoculation treatments sub-plots; three replications.
Paddock history	2014 wheat; 2013 Canola; 2012 Wheat; 2011 Lupin
Stubble management	Sown into a medium density, standing wheat stubble
Fertiliser	80 kg/ha Grain legume super (N:P:K:S 0:13.8:0:6.1) placed 30–40 mm below the seed
Plant population	Sowing rate was adjusted according to seed size and germination to target: 40 plants/m^2 for lupin, field pea and chickpea; 28 plants/m^2 for faba bean; and 130 plants/m^2 for lentil
Sowing	Direct-drilled using a six-row cone seeder with 300 mm row spacing, press wheels and GPS auto-steer
Weed management	Commercial weed management practices used to maintain weed-free conditions to eliminate weed competition and prevent weed seed set
Disease management	No disease management was required this season at Yenda
Insect management	Targeting *Helicoverpa* sp.: 400 ml/ha Fastac® Duo (100 g/L alpha-cypermethrin) applied by the cooperator during late grain fill

Treatments

Varieties (6)	1. Field pea – PBA Oura 2. Faba bean – PBA Rana 3. Lentil –CIPAL0901 4. Lupin – Mandelup 5. Chickpea – PBA Slasher 6. Chickpea – PBA Slasher -seed dressed with P-PICKEL T® fungicide one week before sowing (Chick+F)
Inoculation (4)	1. Peat slurry on seed 2. Peat liquid injected into row 3. Granular (Becker Underwood)* 4. NIL – un-inoculated control
*Granular (Becker Underwood) inoculant for lupin was unattainable and was substituted with Lupin+F (lupin seed treated with P-PICKEL T® fungicide then coated with peat slurry just prior to sowing) Moisture conditions were ideal for sowing after above average autumn rainfall	

Soil

Soil at this site was acidic with pH_{Ca} 4.6 (Table 1) and varied according to the slightly undulating topography. It was a light textured, red sandy-loam along the ridges leading to red loam in the hollows.

Table 1. Site soil chemical characteristics for 0–10 cm and 10–20 cm depth at Yenda, 2014.

Characteristic	Depth	
	0–10 cm	10–20 cm
pH_{Ca}	4.6	6.1
Aluminium Sat (%)	6.4	0
Nitrate nitrogen (mg/kg)	9.8	7
Ammonium N (mg/kg)	0.8	0
Phosphorus (Colwell) (mg/kg)	34	17
Cation exchange capacity (CEC) (cmol(+)kg)	2.8	3.6

Season

The 2014 season at Yenda was warmer, drier and shorter than normal. Rainfall during the critical four months of July to October was only one third of the long-term average (Figure 1, *Lentil sowing rate – Yenda 2014*) and, when combined with warmer temperatures, the season was unfavourable and finished 2–3 weeks earlier than expected. Above-average rainfall preceded the trial (particularly in March), providing valuable soil moisture to help crops to fill grain and finish. Conditions were not conducive to disease, with disease levels low and no fungicides required.

Methodology

Inoculation

The un-inoculated control (NIL) was sown first to avoid residual rhizobia contamination. The liquid formulation was next, followed by the granules and finally the peat-coated seed. The cone and seed tubes were cleaned between treatments. The liquid preparation was formulated by mixing the peat-based product with water then injecting through micro-tubes running directly into the furrow at sowing. The granular formulation was mixed and sown with the seed. All treatments were applied at the recommended rate. Moisture conditions were ideal for sowing after above average autumn rainfall.

Nodule scores

Eight weeks after emergence (20 August), groups of plants with intact roots were randomly dug up with a spade to a depth of 20 cm from four to five locations across each plot. The plants were immediately soaked in water to remove soil for nodule assessment. Plants from each of the four treatments (NIL, peat, liquid and granular) were laid out on a table in the field for visual comparison and scoring (figures 1 and 5). Nodulation was assessed independently by two operators on 10 plants per plot using a 0–5 scale. Data for each plant was recorded individually, but in this report averaged across all 20 scores.

A hand-held GreenSeeker® was used to record the normalised difference vegetation index (NDVI) of plots on 20 August, specifically aiming to quantify nitrogen deficiencies and non-nodulating plots.

Figure 1. Plants from each of the four treatments at Yenda were sampled on 20 August, 2014. They were washed and laid out on a table in the field to allow nodulation scoring.

Results

Nodulation and normalised difference vegetation index (NDVI)

Faba bean and chickpea nodules were almost exclusively restricted to the crown region of the stem and no lateral nodules were present. In contrast, field pea and lentil nodules were scattered throughout the whole root system. Lentil nodules were the smallest and most abundant. Lupin nodules were large and encircled the crown and upper portion of the tap root.

Without inoculation, faba bean and chickpea failed to nodulate at this site (Figure 2), indicating these pulse species had not been cultivated recently and/or had poor colonisation of rhizobia in the soil. Lupin, field pea and lentil however, nodulated abundantly even without inoculation, indicating that effective background rhizobia populations were present.

The peat and liquid inoculant formulations resulted in the most consistent nodulation and the highest nodule scores across all pulses. The liquid formulation resulted in better nodulation of field pea, lentil and faba bean than the other formulations.

Fungicide seed dressing (P-PICKEL T®) had no effect on nodulation at this site.

GreenSeeker® (NDVI) measurement of the plot green-area cover was influenced more by pulse species than inoculant formulation (Figure 3). It was significantly greater in lupin (~0.42), followed by field pea (~0.34), than the other pulses (~0.24). Peat inoculation in faba bean and lupin, however, had a significantly higher NDVI ($P < 0.05$) compared with other inoculant formulations.

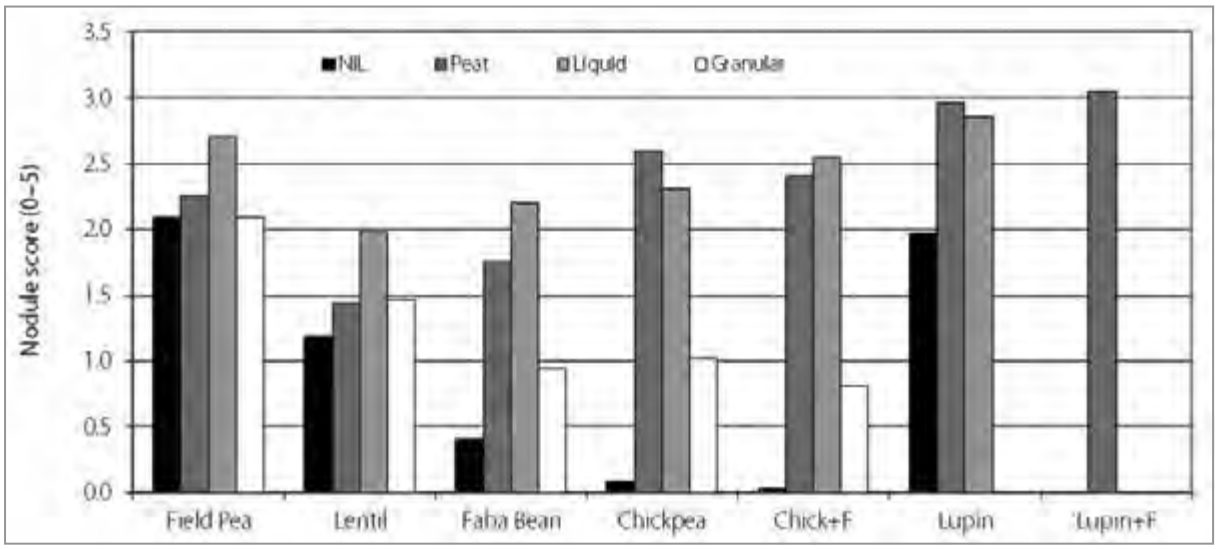

Figure 2. Nodule scores of five pulse species inoculated with different formulations of inoculant at Yenda in 2014. Chickpea included an additional treatment of fungicide seed dressing P-PICKEL T® (Chick+F). Since lupin granular was unavailable at the time, lupin plus P-PICKEL T® seed dressing (Lupin+F) was substituted. Nodule scores were taken on 20 August using a 0–5 scale; 0 = no nodules; 2 = just adequate; 5 = abundant.

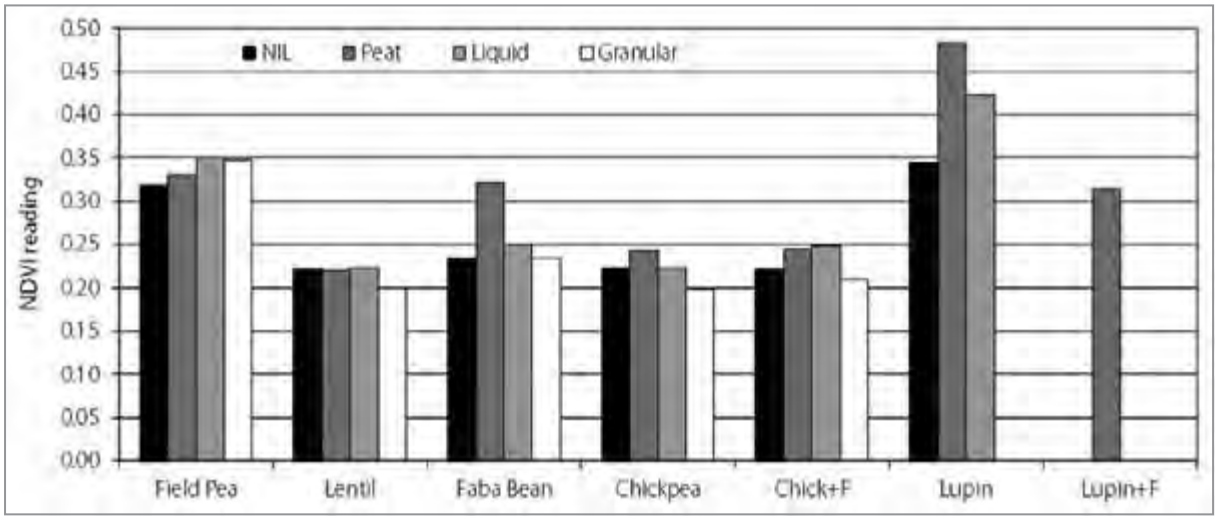

Figure 3. Green-area cover (NDVI) of five pulse species at 20 August when inoculated with different formulations of inoculant at Yenda in 2014.

Grain yield and seed size

Grain yields of the NIL treatment of faba bean and chickpea were significantly lower than other treatments (Figure 3), reflecting their poor nodulation leading to sub-optimal nitrogen nutrition.

Peat and liquid formulations not only resulted in better nodulation (see above), but also higher grain yield (Figure 4).

The P-PICKEL T® seed dressing significantly improved the grain yield in chickpea by around 20% when averaged across the peat, liquid and granular formulations (Figure 4); this result occurred independent of nodulation (Figure 2). The reason for this was not clear.

Inoculant formulation had little or no effect on seed size (g/100 seeds). The average seed sizes for field pea, lentil, faba bean, chickpea and lupin were 21.0, 3.9, 65.1, 18.9 and 14.9 g/100 seeds respectively.

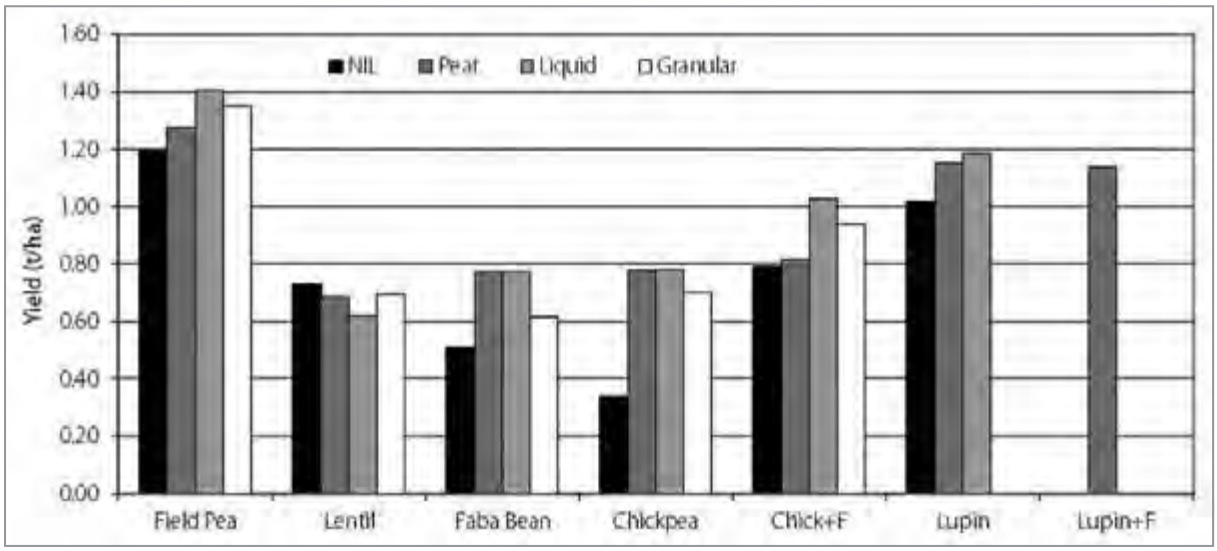

Figure 4. Grain yield (t/ha) of five pulse species inoculated with different formulations of inoculant at Yenda in 2014. Chickpea included an additional treatment of fungicide seed dressing P-PICKEL T® (Chick+F). Also, lupin granular was unavailable at the time so lupin plus P-PICKEL T® seed dressing (Lupin+F) was substituted.

Figure 5. Examples of chickpea plants treated with different inoculant formulation, Yenda 2014. The respective nodule scores from left to right are 0, 1, 2 and 3.

Acknowledgements

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