Evaluating Different Legume Crops and Inoculation Options

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Key Messages

- All three crops (lupin, faba bean and chickpea) had significantly higher nodulation scores on the light acidic loam compared to the red loam trial.
- For chickpea, two new acid-tolerant rhizobia strains, developed by Murdoch University, had significantly higher average nodulation formation over the other inoculants.
- No significant differences were observed between the inoculate types (granular, peat and liquid) for any of the crops.
- The trial could not be harvested due to poor performance in a dry year.

Aim

This trial aims to demonstrate and assess the benefits of growing legumes and provide a better understanding of how to maximise gross margins and nitrogen recovery.

Background

The cultivation of grain legumes provides nutritious food, improves soil health, and reduces nitrogen fertiliser in farming systems. Significant increases in domestic and international demand for West Australian grain legumes are forecast due to burgeoning global populations, improvements in market access, as well as our geographic advantage.

Grain legumes currently contribute in a small and diminishing way to the profitability of West Australian farming systems. GRDC analysis indicates farmers have a good awareness of the benefits of growing a legume in their rotation but have concerns about pulse reliability and profitability. There have been recent advances in grain legume genetics, acid-tolerant rhizobia, management strategies, and weed and disease protection products.

These trials are part of a large-scale collaborative project led by the Grower Group Alliance, which includes 13 grower groups that are demonstrating different legume options and management techniques.

This trial specifically looks at the performance of three legume varieties, when using different inoculation products. This trial has been conducted on a light acidic sandy loam and a red loam. The three inoculation products in the trial were ALOSCA (granular), BASF Nodulaid (peat) and New Edge Microbial Ezi Rhi (liquid). Three experimental peat lines have been included, specifically designed by Murdoch University with tolerance to acid soils.

Trial Details

Trial location	KL Carter & Co., Jibberding
Plot size & replication	10m x 1.5m x 3 replications
Soil type	Sand (light) and sandy clay loam (red)
Paddock rotation	2020 wheat, 2021 wheat, 2022 wheat
Sowing date	19/05/2023
Sowing rate	86 kg/ha Jurien lupin (target 45 plants/m^2), 222 kg/ha PBA Bendoc faba bean (target 30 plants/m^2, 115 kg/ha CBA Captain chickpea (target 45 plants/m^2)
Fertiliser	19/05 - 80 kg/ha MacroPro Extra
Herbicides, Insecticides & Fungicides	19/05 - 1.5 L/ha trifluralin, 1.0 L/ha glyphosate, 1.1 kg/ha simazine, 1 L/ha chlorpyrifos, 150 ml/ha bifenthrin, 27/07 - 330 ml/ha clethodim 360 EC, 150 ml/ha quizalofop-p-ethyl, 10/08 - 20 ml/ha gamma-cyhalothrin, 600 ml/ha bixafen/prothioconazole
Harvest date	Trial was unable to be harvested

Treatments

Treatment	Chickpea	Faba Bean	Lupin
1	WSM5041 (peat 1)*	Alosca Gp F	Alosca Gp G
2	WSM5043 (peat 2)*	EziRhi Gp F	EziRhi Gp G
3	541B1 (peat 3)	Nodulaid Gp F	Nodulaid Gp G
4	Alosca Gp N	Control	Control
5	EziRhi Gp N		
6	Nodulaid Gp N		
7	Control		

*Treatment only occurs on light soil trial.

Soil Composition- Light Soil Trial

Depth (cm)	pH ($CaCl_2$)	Col P (mg/kg)	Col K (mg/kg)	S (mg/kg)	N (NO_3) (mg/kg)	N (NH_4) (mg/kg)	EC (ds/m)	OC (%)
0-10	6.1	27	72	5.8	2	4	0.040	0.57
10-20	5.8	24	50	8.1	< 1	2	0.034	0.33
20-30	5.0	9	43	17.4	< 1	2	0.033	0.19

Soil Composition- Red Soil Trial

Depth (cm)	pH ($CaCl_2$)	Col P (mg/kg)	Col K (mg/kg)	S (mg/kg)	N (NO_3) (mg/kg)	N (NH_4) (mg/kg)	EC (ds/m)	OC (%)
0-10	6.7	11	462	8.7	2	2	0.226	0.68
10-20	7.1	9	386	7.6	2	1	0.264	0.51
20-30	7.4	7	411	11.5	2	1	0.353	0.43

Results

Table 1. Predicta B soil testing (pre-seeding) showing resident rhizobia levels. Rhizobia numbers are shown as log(rhizobia)/g soil. (BD) = below detection, (L) = low and (M) = medium levels of rhizobia in the soil.

Trial	Rep	Rhizobia Group N (Chickpea)	Rhizobia Group F (Raba Bean)	Rhizobia Group G (Lupin)
Light Soil	2	0 (BD)	3.28 (M)	2.64 (L)
Light Soil	3	0 (BD)	2.99 (M)	2.95 (L)
Red Soil	1	0 (BD)	1.57 (L)	2.18 (BD)
Red Soil	2	0 (BD)	0 (BD)	2.37 (L)
Red Soil	3	2.36 (L)	0 (BD)	2.23 (BD)
20-30	7.4	7	411	11.5

Table 2. Establishment counts (plants/m²) were conducted on 15 June, approximately four weeks post-seeding.

	Chickpea		Faba Bean		Lupin	
Inoculant	Light	Red	Light	Red	Light	Red
Ezi Rhi	29	34	24	27	43	27
Nodulaid	32	34	31	24	39	54
Alosca	33	24	29	26	39	24
Control	27	35	28	31	43	43
Peat 3	26	24				
Peat 2	29					
Peat 1	23					
Average	28	30	28	27	41	37

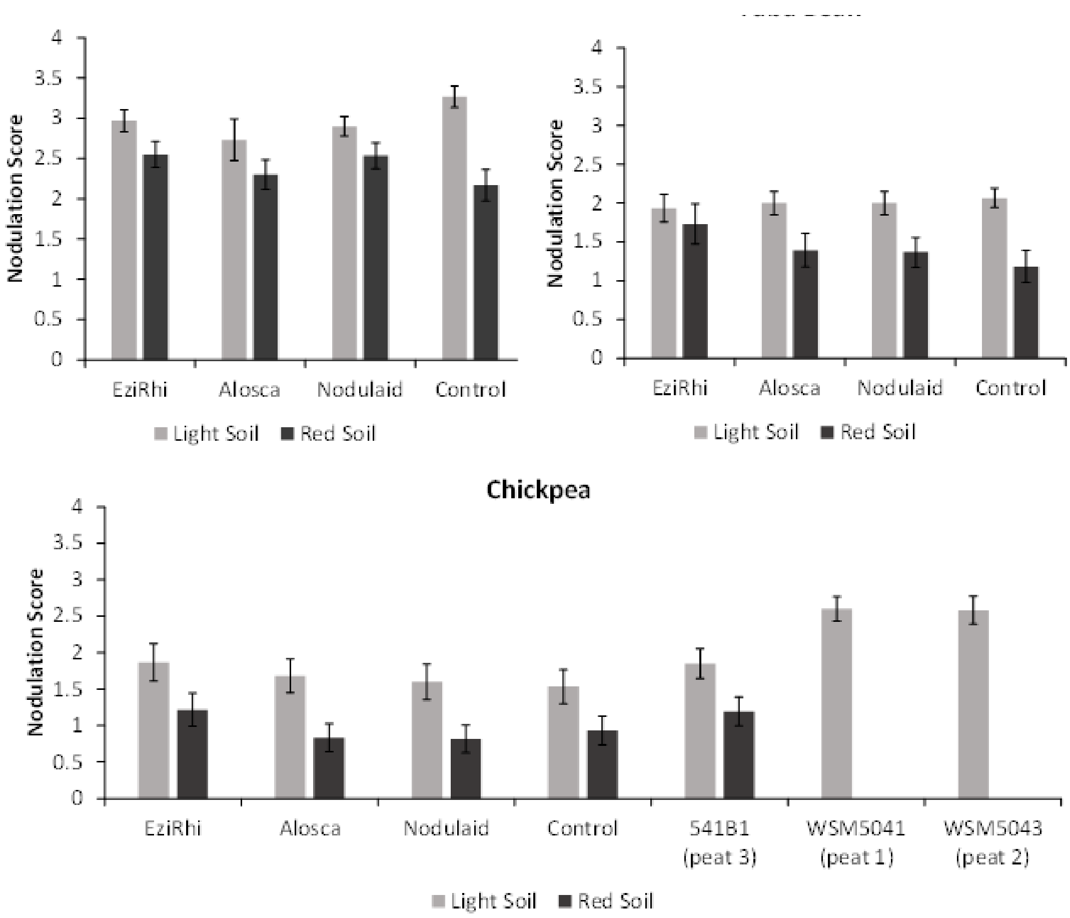

Figure 1. Average nodulation score (0-10) for all treatments of inoculants on lupin, faba bean, chickpea crops for both the light and red soil trials. Treatments are shown with standard errors of the means.

Background rhizobia soil testing shows low levels of Group G rhizobia strain (lupin) in both the light and red soil. Group F rhizobia strains (faba bean) had a medium presence in the light soil, and a low or below detection level in the red soil. Group N rhizobia strains were only present in rep 3 of the red trial at low levels.

Across all crops and treatments, there were significant differences between the light and red soil trials, in terms of average nodulation score ($p < 0.05$). Within the crops, only Murdoch University's experimental chickpea rhizobia peat lines, WSM5041 and WSM5043, had significantly higher average nodulation scores compared to all other inoculates ($p < 0.05$). The freeze-dried liquid inoculant, EziRhi, had the highest average nodulation scores for all crops on the red soil trial, however not significantly ($p > 0.05$).

Comments

Legumes can play a pivotal role in farm rotations due to their dual benefits: serving as a break crop and their ability to fix nitrogen. To ensure optimal nitrogen fixation, it is essential to understand the biology of rhizobia-legume symbioses and inoculation options to improve productivity and sustainability.

The three legume crops examined in this trial exhibit varying soil pH preferences: lupin can tolerate acidity (soil pH of 4.5–8.0), faba bean slightly less so (soil pH of 5.5-8.0), and chickpea prefer a more neutral/alkaline soil (soil pH of 6.0-8.5) (O'Hara, et al. 2012). This was reflected in the establishment counts, with lupin having significantly higher establishment counts in the light soil ($p < 0.05$) with plant numbers closer to the target of 45 plants/m^2 compared to the red soil trial (Table 2). Faba bean maintained similar rates in both soil types (n.s.) and was the closest crop to approach its target of 30 plants/m^2. Chickpea had slightly higher establishment counts in the red soil trial (characterised by a more neutral pH) compared to the light soil trial (n.s.), however chickpea was notably below the target of 45 plants/m^2 in both soil types.

Through-out the growing season, especially as the conditions became dry, the light soil plots were observed to be in a 'healthier' condition than the red soil trial. This may be attributed to deeper penetration of the root systems, enabling access to sub-soil moisture. Consequently, the light soil plots had significantly higher average nodulation scores than their red soil counterparts (Figure 1).

In terms of the inoculants, no single standout option emerged from the commercial options for any crop on either soil type. In the red soil trial, the EziRhi inoculant treatments had the highest average nodulation score for all crops, however this was not statistically significant (Figure 1). New Edge's EziRhi inoculant is a freeze-dried powder that was mixed with water to coat the seed. This method contains a higher cell count of rhizobia compared to granular and peat products (Denton, et al. 2018). Further field testing is required to determine the efficacy of the different inoculation options, with a focus on rhizobia survival.

For lupin and faba bean in the light soil trial, no significant difference was observed between treatments, with the control having the highest average nodulation score. Background rhizobia soil testing conducted prior to sowing shows a low and medium presence of lupin and faba bean rhizobia strains in the light soil, respectively, which could explain the result (Table 1). However, this unexpected result could also suggest a potential limitation of the trial with possible contamination within the seeding box during implementation. Additionally, the trial was dry sown, which is suboptimal for rhizobia survival, serving as another limiting factor.

Despite these results, within the chickpea treatments on light soil, two of Murdoch University's experimental peat lines, WSM5041 and WSM5043, had significantly higher average nodulation scores compared to all other inoculants (Figure 1). Those two strains were specifically developed for their acid tolerance, suggesting higher rhizobial survival in the light acid soil, which would explain the increased formation of nodules.

Acknowledgements
Thank you to Boyd Carter for hosting the site and Living Farm for seeding and managing the trial. This trial is part of a GRDC investment into grain legume extension being led by the Grower Group Alliance. Thanks to BASF, New Edge Microbials, Elders Dalwallinu, Yvette Hill (Murdoch University) and Rob Nankivell for supplying products and advice.

References
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Peer Review
Mark Seymour, Senior Research Scientist, DPIRD

Survey
GGA has created a survey to better understand growers' opinions of legumes. It would be greatly appreciated if you could please complete the survey, using the QR code.

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