Demonstrating opportunities for improved pulse nodulation

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Key points

- Where there was no paddock history of chickpea and an absence of suitable rhizobia, doubling the inoculation rate resulted in the highest level of nodulation.
- A lentil crop sown in a paddock (pH 4.8–5.2) with a low background level of lentil rhizobia had good nodulation, demonstrating that not all paddocks are responsive to inoculation.
- At St James, the combination of seed inoculation and Calciprill® (granulated calcium carbonate) at depth resulted in the greatest yield in chickpeas grown on an acid soil, however multiple factors may need to be addressed to capture yield benefits.

Background and aim

As well as generating useful income, pulses provide significant benefits to following crops, with nitrogen (N) fixation boosting the supply of this critical nutrient to subsequent crops. However, not all pulses produce nitrogen-fixing nodules, rendering them unable to reach their nitrogen-producing potential, especially on acidic soils.

The demonstration trials in this report were sown as part of a GRDC investment aiming to improve the nitrogen fixation of winter pulse crops and to promote their wider adaptation and adoption. The project involves promoting effective inoculation and pulse management practices, raising awareness and knowledge around pulse nodulation and nitrogen fixation as well as the impact of soil acidity on crop yields.

A number of organisations across the GRDC Southern Region are involved in the project including: Mallee Sustainable Farming (lead organisation), the South Australian Research and Development Institute (SARDI), AgCommunicators, Bates Ag, Rural Directions, Southern Farming Systems, Birchip Cropping Group, Ryder Ryan Research Pty Ltd, Moodie Agronomy, Riverine Plains Inc, Southern Pulse Extension, and Trengove Consulting.

In order to demonstrate best practice inoculation in pulse crops on acid soils in northern Victoria, two demonstration sites at St James were sown to lentils and chickpeas while a third site was sown to faba beans at Bungeet. Inoculant treatments varied by site and crop type and were decided in consultation with the host farmer and the nitrogen-fixation project research team. At the host farmer's suggestion, Calciprill® (granulated calcium carbonate) was included as an additional treatment at the St James chickpea site to investigate its potential to address a suspected acid subsoil issue.

Farmer co-operators hosted the GRDC Riverine Plains Inc *Dookie Pulse Check Discussion Group* at the sites during 2019.

Method

The 2019 pulse inoculation demonstrations were sown at three sites in the St James and Bungeet areas using the host farmers' sowing equipment. Sites were sown to either lentils, chickpeas or faba beans as described in Table 1. All sites were soil sampled on 4 March, 2019, with 0–10cm depth samples sent to SARDI for pH and background rhizobia level testing. Background rhizobia level tests were carried out using a plant trap method in pots and also using DNA testing to estimate rhizobia number.

Nodulation was assessed at all sites on 23 July 2020. Six plants per treatment were dug out, soaked and rinsed and all effective nodules counted and scored as per Table 2.

Lentil demonstration site, St James

The lentil demonstration at St James included nil inoculum, a commercial inoculant (WSM-1455) and two acid-tolerant inoculant (SRDI-969 and SRDI-970) treatments (Table 1). Demonstration site treatments and areas are also given in Table 1. The nil inoculum treatment was 370m long and one seeder width (12m) wide, giving a total demonstration area of 0.44ha. The commercial inoculum treatment was two seeder widths (24m) wide, giving a total demonstration site area of 0.88ha. The two acid-tolerant rhizobia treatments were three seeder widths (36m) wide, giving a total demonstration site area of 1.33ha.

The lentils were sown on 6 May, 2019, and were harvested on 20 November, 2019, with yields measured using the farmer's grain yield monitor.

TABLE 1 Nitrogen-fixation demonstration site information, soil type, pH, background rhizobia levels and treatment

	Demonstration 1		Demonstration 2		Demonstration 3	
Pulse crop	**Lentils**		**Chickpeas**		**Faba beans**	
Location	**St James**		**St James**		**Bungeet**	
Cultivar	PBA Ace		Genesis 090		Samira	
Soil type	Mixed		Brown clay loam		Brown clay	
Soil pH ($CaCl_2$) 0–10cm	4.8–5.2		5.6		5.5	
Background rhizobia levels	Low levels lentil/faba* bean rhizobia		No chickpea rhizobia detected		Medium levels lentil/faba* bean rhizobia.	
	Treatment	**Plot size**	**Treatment**	**Plot size**	**Treatment**	**Plot size**
	Nil inoculation	12m x 370m (0.44ha)	Nil inoculation	12m x 240m (0.29ha)	Nil inoculation	33m x 200m (0.66 ha)
	Commercial peat inoculant (strain WSM-1455)	24m x 370m (0.88ha)	Single rate (3.5kg/ha) Tag Team® granules	36m x 240m (0.86ha)	Single rate Tag Team granules (3.3kg/ha)	33m x 200m (0.66 ha)
	Peat inoculant (acid-tolerant strain SRDI-969)	36m x 370m (1.33ha)	Double rate (7kg/ha) Tag Team granules	36m x 240m (0.86ha)	-	-
	Peat inoculant (acid-tolerant strain SRDI-970)	36m x 370m (1.33ha)	Single rate (3.5kg/ha) Tag Team granules + Calciprill (100kg/ha)	36m x 240m (0.86ha)	-	-

* The same strain of rhizobia (Group F) inoculates both lentils and faba beans

TABLE 2 Nodulation scorecard used to assess the number and distribution of nodules from plants collected across the demonstration treatments

Nodule score	Distribution of effective nodules	
	Crown (top 5cm)	>5cm root
0	0	0
0.5	0	1–4
1	0	5–9
1.5	0	>10
2	<10	0
2.5	<10	<10
2.75	<10	>10
3	>10	0
4	>10	<10
5	>10	>10

Source: Brockwell and Gault (1977) in AGrow, Final technical report, 2018, southern NSW Trials, Improving nitrogen fixation in lentils.

Chickpea demonstration site, St James

The chickpea demonstration included nil inoculum, a single and a double rate of Tag Team granular inoculant and a single rate of Tag Team granular inoculant + Calciprill treatment (Table 1). All demonstration plots were 240m long. The nil-inoculum treatment was one seeder width (12m) wide giving a total demonstration site area of 0.29ha, while all other treatments were three seeder widths wide (36m) giving a total demonstration site area of 0.86ha.

The chickpeas were sown on 6 May, 2019. The Tag Team plus Calciprill treatment was applied at sowing through a DBS airseeder and placed below the seed at approximately 15cm deep. The chickpeas were harvested on 19 December, 2019 and yields were measured using the farmer's yield monitor.

Faba bean demonstrations site, Bungeet

The faba bean demonstration site compared the nil-inoculum treatment to a Tag Team granular treatment. The treatments, sown on 7 May 2019, were each three seeder widths wide (33m) and 200m long giving a total demonstration site area of 0.66 ha (Table 1). Technical issues meant the faba beans were hand-harvested on 6 December 2019, with 6 x 2m rows sampled in both treatment strips. Samples were then weighed and averaged.

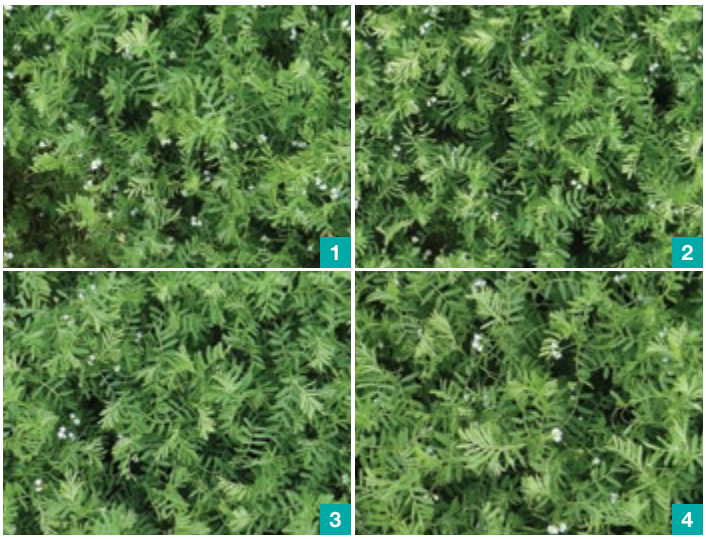
Results

Lentil trial, St James

The acid-tolerant inoculant strains SRDI-969 and SRDI-970 had nodulation scores >4.5, while the commercial inoculant treatment had a nodulation score of 2.9 (Table 3). Nodulation was not correlated with grain yields. Yields in this trial ranged from 0.75t/ha for the acid-tolerant SRDI-969 rhizobia treatment to 1.07t/ha for the nil treatment, while the rest of the farmer's paddock averaged 1.0t/ha (range of 0–3.7t/ha).

TABLE 3 Lentil nodulation scores and grain yields, St James, 2019

Treatment	Nodulation score (1–5)	Yield (t/ha)
Nil inoculum	3.9	1.07
Commercial WSM-1455	2.9	1.06
Acid tolerant SRDI-969	4.6	0.75
Acid tolerant SRDI-970	5.0	0.86



*Lentil demonstration treatments at St James, September 2019; **1.** Nil inoculation, **2.** Commercial peat inoculant (strain WSM-1455), **3.** Peat inoculant (acid-tolerant strain SRDI-969), **4.** Peat inoculant (acid-tolerant strain SRDI-970).*

Dry conditions and late frost likely limited yield potential at this site. Growing season rainfall was Decile 1 (209mm), as measured by the Yabba South Riverine Plains Inc network weather station and there were 11 days below 3°C during October and 4 days below 3°C during November.

Chickpea trial, St James

All inoculated treatments at St James had higher nodulation scores compared with the nil treatment, with the greatest nodulation score in the double-rate inoculation treatment (Table 4). Yields were low at this site and ranged between 0.33–0.73t/ha. The only treatment that had a higher yield than the nil treatment (0.40t/ha) was the single rate Tag Team + 100kg/ha Calciprill drilled below the seed treatment (0.73t/ha). The rest of the farmer's paddock averaged 0.37t/ha, with yield ranging between 0–1.8t/ha.

TABLE 4 Chickpea nodulation scores and yields, St James

Treatment	Nodulation score (1–5)	Yield (t/ha)
Nil inoculum	0.8	0.40
Single rate Tag Team granules (3.5kg/ha)	3.0	0.33
Double rate Tag team granules (7.0kg/ha)	4.2	0.33
Single rate Tag Team granules (3.5kg/ha) + Calciprill (100kg/ha)	3.1	0.73

TABLE 5 Faba bean nodulation scores and yields, Bungeet

Treatment	Nodulation score (1–5)	Yield (t/ha)
Nil	5	2.76
Single rate Tag Team granules (3.5 kg/ha)	5	3.13

The dry season and late frost also may have limited yield potential at this site. Growing season rainfall was Decile 1, as measured by the nearby Yabba South Riverine Plains Inc network weather station, with late frosts also recorded in the area. At the Southern Pulse Agronomy site at Dookie, researchers also observed the poor performance of chickpeas relative to other pulses and suggested that cool conditions at flowering and pod-fill may have also adversely affected grain yield.

Faba bean trial, Bungeet

The paddock at Bungeet has a history (more than 10 years) of faba bean production and had previously been limed (pH_{Ca} 5.5), with pre-sowing tests indicating a substantial background level of rhizobia in the soil (Table 1). The nil treatment was well nodulated (Table 5), which validated the pre-sowing background rhizobia test results. No visual difference in crop growth was observed between the two treatments, which yielded 3.13t/ha for the inoculated treatment and 2.76t/ha for the nil treatment.

The Riverine Plains Inc network weather station data at Bungeet recorded 21mm more growing season rainfall than received at the Yabba South weather station, though it also a showed greater number of days with minimum temperatures below 3°C. Beans have a higher frost tolerance compared to lentils and this, combined with the increased rainfall and higher overall yield potential, may have resulted in higher relative yields at this site.

Observations and comments

Background soil testing for rhizobia is being trialled as a potential service for growers and will likely require soil sampling to occur in mid-February (researchers are investigating methods for sampling earlier in the year, or the year prior, to give growers more time to make inoculant decisions). In these demonstrations, background soil testing corresponded well to actual nodulation results observed in the field and this indicates background rhizobia testing could provide farmers and their advisors with accurate information regarding the requirement for inoculation.

The chickpea site benefited from the use of inoculum, while inoculation was probably not required for the paddock sown to faba beans, as indicated by the background rhizobia tests. For the faba bean paddock, the trend for increased yield with inoculant may have been due to the phosphorus solubiliser in the Tag-Team inoculant.

Acid-tolerant rhizobia (Group F for faba bean and lentil) are being trialled to verify their performance across a range of environments before they are released for pulse growers. Although the acid-tolerant rhizobia used in the lentil trial resulted in good nodulation, they did not increase yield, but have done so in other trials not limited by seasonal conditions.

For chickpeas grown on an acid soil at St James, applying 100kg/ha Calciprill at depth in combination with a standard rate of granular inoculant resulted in the highest yield. A response to this rate of Calciprill (100kg/ha) was not expected (usually lime is applied at 10–25 times that rate (i.e. 1–2.5t/ha), however the Calciprill was applied to a suspected acid layer, at 15–20cm, which may explain the results. Further investigation into Calciprill may be warranted for this area. There was no background level of chickpea inoculum detected at this site and doubling the rate of inoculation resulted in the highest nodulation scores.

Acknowledgements

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