Optimising legume inoculation for dry sowing

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RESEARCH

Location:
Minnipa - Bruce Heddle
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2018 Total: 244 mm
2018 GSR: 178 mm
Soil Type
Red sandy loam, pH($CaCl_2$): 7.8
Plot Size
12 m x 1.7 m x 4 reps

Key messages

- **Standard inoculation practices are unlikely to deliver satisfactory nodulation where pulses are sown into dry soils.**
- **Pea and chickpea sown late (26 June) had the higher nodulation and crop production than those sown dry. Where the soil remained dry for 20 days after sowing nodulation was poor, regardless of the inoculation strategy used.**
- **Nodulation of pea was low regardless of sowing time at Minnipa in 2018. Both peat applied to seed and granule formulations resulted in similar nodule numbers per plant.**
- **Nodulation can be improved when dry sowing if inoculation rate of peat is increased. Doubling the rate of inoculation significantly improved pea nodulation.**
- **The performance the rhizobial granules was inconsistent. A granule produced at SARDI was more effective in one experiment, but not the other. Two commercial granules provided no advantage compared to peat applied to seed.**

Why do the trial?

In the past 15 years the area sown to pulses in South Australia has increased by 50% (ABARES 2015) and continues to expand as new pulse varieties become available with improved herbicide, disease and soil constraints tolerance. Dry sowing legumes allows growers to better manage time demands around sowing, ensure successful early establishment of crops and reduce yield losses in dry springs.

The trials at Minnipa were part of a larger program to assess a range of commercial rhizobia inoculant products, application strategies and sowing times to provide growers with recommendations that ensures adequate nodulation and nitrogen fixation in dry sown crops.

Inoculation provides one of the most cost effective ways to improve legume performance where the legume (or another from the same inoculation group) has not previously been grown and/or where conditions are detrimental to the survival of rhizobia in the soil.

There is less risk of poor crop nodulation when a background of soil rhizobia is present. On Eyre Peninsula chickpea is nearly always responsive to inoculation.

How was it done?

Two replicated trials were sown on a sandy soil of $pHCaCl_2$ 7.8 on the property of Bruce Heddle's at Minnipa on Eyre Peninsula. Previous soil tests had indicated the site was likely to be responsive to inoculation for field pea and chickpea, due to the absence of suitable rhizobia in the soil.

Trial 1: Peat v granule at different sowing times

One of the difficulties of comparing commercial granule products is that they are manufactured using various substrates (often not peat based), which can make the comparison and interpretation of their performance difficult. To enable a valid comparison of the delivery platform (rhizobia in a granule vs. rhizobia in a peat applied to seed) we made moist peat and peat granule inoculants at SARDI for both chickpea and field pea in 2018. Both contained high numbers of their corresponding rhizobia.

The first trial had three times of sowing (13 April, 26 April and 6 June, Figure 1), two crops (Genesis090 chickpea and PBA Oura pea) and three inoculation treatments (no rhizobia applied, moist peat inoculant applied as a slurry to seed, and peat based granule).

All inoculants were applied at the recommended commercial rates. Peat slurry treatments were applied on seed and sown within 24 hours and granules were sown in furrow with seed.

Nodulation (number and weight per plant) was measured 10 weeks after crop emergence, peak biomass production was measured at mid pod fill for time of sowing (TOS) 3 and end pod fill for TOS 2. Where possible plots were harvested with a plot harvester and grain yield measured. Nitrogen fixation is still being determined.

Trial 2: Commercial products and inoculation rate

Two trials were sown, one for field pea (PBA Oura) and one for chickpea (Genesis 090) on 26 April to compare the performance of commercial inoculant formulations when sown dry. Due to the exceptionally dry season the chickpea trial was unsuccessful and only results from the field pea trial are presented.

There were eight treatments in the pea trial, including an un-inoculated (nil) control. All further treatments contained the commercial rhizobia strain for field pea (WSM1455–Group F) provided in SARDI made peat applied at two different rates, in a SARDI made granule, or in peats or granules supplied by two of the commercial inoculant companies (Table 1). All inoculants were applied at the recommended commercial rates (RR), except for SARDI peat which was also applied at double the RR. Peat slurry treatments were applied on seed within 24 hours of sowing and granular products were sown in furrow with seed. It should be noted commercial peat applied as slurry is currently not recommended for dry sowing.

Measurements made as for Trial 1.

What happened?

Trial 1

The soil at the trial site had no known pulse cropping history and therefore no pea or chickpea rhizobia were present in the soil at sowing. As a result, plants in the un-inoculated (nil) treatments for both crops did not form nodules.

Overall, the conditions for nodulation and crop growth in 2018 were challenging. Treatments sown on 13 April (TOS 1) and 26 April (TOS 2) germinated in early May, however were affected by an extended dry period until mid-June. As a result, the total number of nodules measured 10 weeks after the crop emerged (14/8 for TOS1, TOS2 and 19/9 for TOS3) was low (averaging just 10 nodules per plant for field pea, which is well below the level of 50 that is often measured). Despite the low levels of nodulation, significant treatment effects were measured (Figure 2).

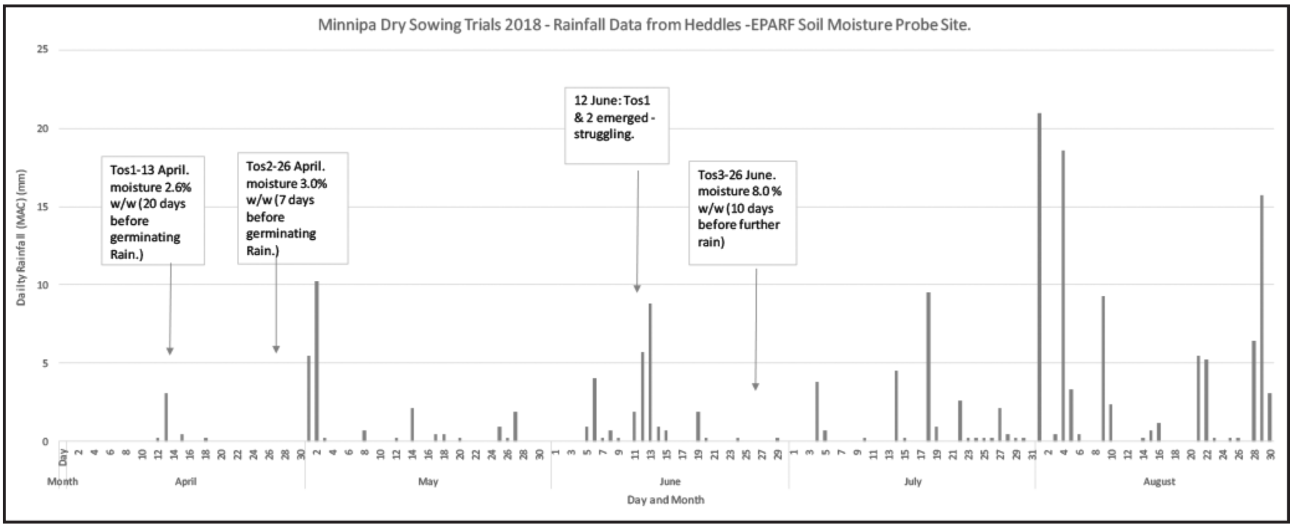

Figure 1 Rainfall and sowing times for trials at Minnipa in 2018

Table 1 Inoculation treatments and application rate for Trial 2

Treatment	Formulation	Application Rate
Nil	Un-inoculated	0
SP	SARDI peat	*RR
SP2.0	SARDI peat	2 x RR
SG	SARDI granule	4.8 kg/ha
NP	#Novozymes Tag-Team Peat	RR
NG	Novozymes Tag-Team Granule	4.5 kg/ha
BP	BASF Nodulaid Peat	RR
BG	BASF Nodulator Granule	5.0 kg/ha

** Recommended Rate*
 # Novozymes has been acquired by Monsanto

For chickpea, nodulation of plants in the dry sown treatments (TOS 1 and TOS 2) was negligible for all inoculation treatments. However, for TOS 3 (break of season) when some soil moisture was present, the SARDI granule treatment resulted in the most nodulation, with the majority of nodules on lateral roots. For field pea, both peat and granule treatments significantly increased nodulation above the Nil treatments at TOS 2 and TOS 3. The granule treatment performed as well or better than peat on seed at both of the later sowing times.

Due to the restricted growth of the crop due to below average rainfall, peak biomass estimates were only made for TOS 2 and TOS 3 sown treatments and only TOS 3 treatments were harvested. There were no significant treatment effects (Table 2).

Trial 2

The nodulation of field pea sown into dry soil on 26 April (TOS 2) was improved by inoculation. The SARDI made moist peat applied to seed at double RR was the most effective treatment. However as for Trial 1, nodule number per plant was below the benchmark of 50 per plant commonly measured under optimal sowing conditions. When applied to seed at RR, the performance of the SARDI and commercial formulations of moist peat was similar (Figure 3). Although not significant, moist peat treatments had slightly better nodulation than granule treatments.

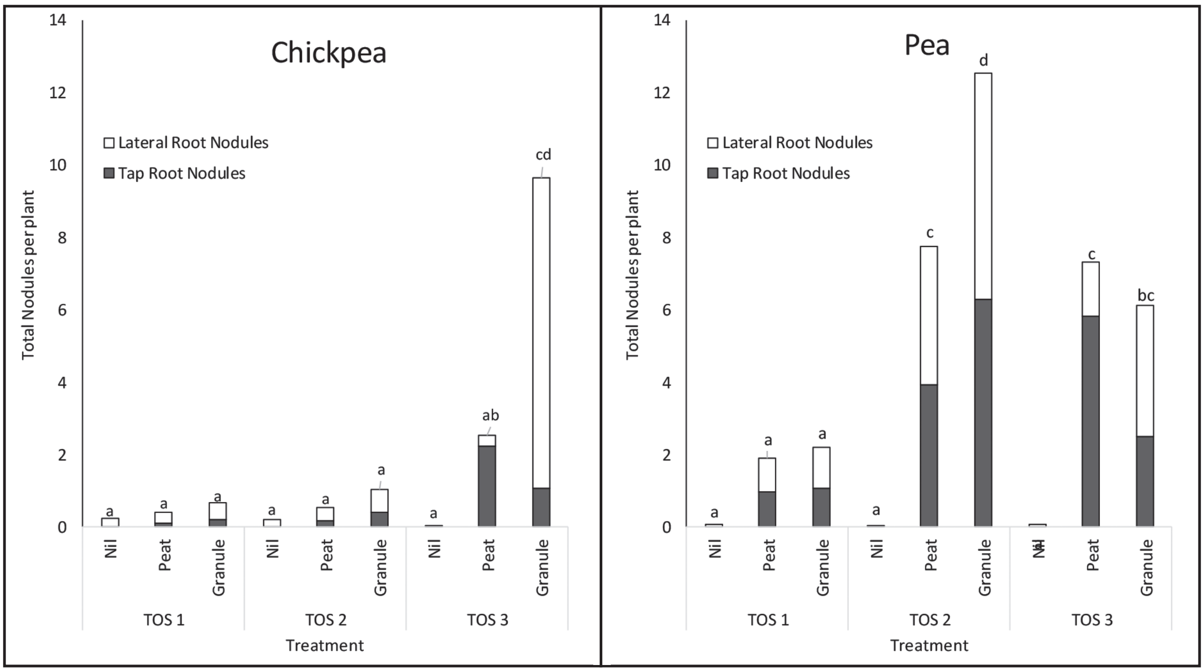

Figure 2 The number of nodules on the tap roots and lateral roots was measured 10 weeks after emergence
Letters above columns indicate significance for Total Nodule Number per plant at P<0.05, where by columns with the same letters are not significantly different.

Table 2 Impact of sowing time and inoculant formulation on biomass production (mid pod fill) and yield for chickpea and field pea at Minnipa. No significant differences at P<0.05.

Sown	Crop	Formulation	Peak Biomass (t/ha)	Yield (t/ha)
TOS 2 Dry	Chickpea	Nil	0.21	not harvested
		Peat	0.17	
		Granule	0.17	
	Pea	Nil	0.40	
		Peat	0.42	
		Granule	0.51	
TOS 3 Break	Chickpea	Nil	0.49	0.17
		Peat	0.47	0.17
		Granule	0.59	0.18
	Pea	Nil	0.41	0.14
		Peat	0.68	0.24
		Granule	0.60	0.23

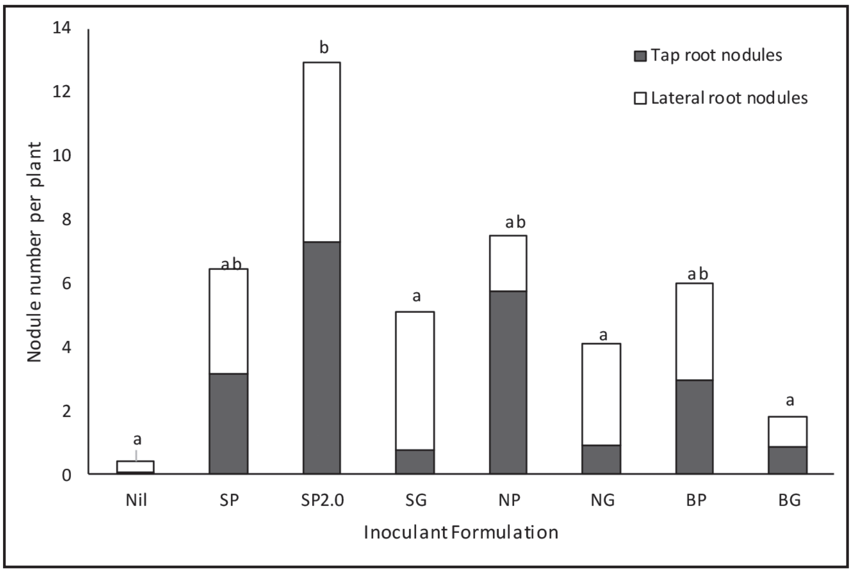

Figure 3 Impact of inoculant formulation on nodulation of dry sown field pea (PBA Oura). The number of nodules on the tap roots and lateral roots was measured 10 weeks after emergence. *Letters above columns indicate significance for total nodule number per plant at P<0.05, where by columns with the same letters are not significantly different.*

Table 3 Impact of inoculant formulation non biomass production (mid pod fill) and grain yield of dry sown field pea at Minnipa. P<0.05, where by values with the same letters are not significantly different.

Treatment	Formulation	Peak biomass (t/ha)	Yield (t/ha)
Nil	Un-inoculated	0.35 a	0.11 a
SP	SARDI peat	0.75 d	0.25 c
SP2.0	SARDI peat (2 x rate)	0.69 cd	0.24 c
SG	SARDI granule	0.61 bcd	0.18 abc
NP	#Novozymes Tag-Team Peat	0.59 bcd	0.21 bc
NG	#Novozymes Tag-Team Granule	0.60 bcd	0.20 bc
BP	BASF Nodulaid Peat	0.51 abc	0.14 ab
BG	BASF Nodulator Granule	0.45 ab	0.15 ab

** Recommended Rate*
 # Novozymes has been acquired by Monsanto

As in Trial 1, maximum biomass production and yield were limited by the below average growing season rainfall. Despite this, most inoculated treatments produced significantly more biomass and yield than the un-inoculated controls, with the SARDI peat applied at both rates performing best (Table 3).

How does this compare to elsewhere in SA?

Several other field trials (Wanilla - bean 2017, Farrell Flat - lupin 2017, Lameroo - chickpea 2018) have demonstrated that there is a significant correlation between the number or rhizobia applied (either in peat applied to seed or in granules applied in furrow) and the subsequent nodulation of the crop when dry sown.

- When peat is applied to seed at twice the recommended rate there have been significant and consistent improvements in nodule number per plant.
- When the number of rhizobia in granules is high (i.e. quality granule) the outcome for nodulation and biomass production has generally been good.

What does it mean?

Where inoculation of a pulse crop is necessary (due to an absence of suitable soil rhizobia) using standard rates of peat slurry on seed when dry sowing has rarely been the most effective inoculation strategy and often resulted in sub-optimal nodulation, especially if extended dry conditions are combined with other stresses such as low pH.

The duration of the dry period between sowing and germination is significant to the outcome. In Trial 1, where this was 20 days (TOS 1), nodulation was poor, regardless of the legume type or inoculation strategy used. At TOS 2 the chickpea symbiosis was most sensitive, forming few nodules even though it was only 7 days before significant rain. Very early sowing should be restricted to paddocks that already contain suitable rhizobia, since the nodulation in inoculation responsive paddocks will almost certainly be compromised.

Improved nodulation was consistently achieved by doubling the rate of inoculation when dry sowing. This result was observed in the trials at Minnipa as well as several other trials across the duration of the project.

The performance of granules has been inconsistent, both here and in other trials. The promising performance of the SARDI granule in Trial 1 (TOS 2 for pea), was not repeated in Trial 2. The reasons for this are not clear, since the exact same granule was used. The commercial granules provided no advantage in Trial 2, although at other trial sites they have. Variation in granule quality (the number of rhizobia they contain) has been measured and is one factor that has affected their performance (data not shown). Their quality standard is the responsibility of the manufacturer and therefore carries more risk than peat inoculants which have to comply with minimum standards which are independently tested. The influence of soil type on granule performance is still not well understood.

Nodulation in the two trials for field pea was at best 12 per plant, which is well below that of 50 nodules per plant (10 weeks after sowing) that we often observe. While this may indicate below potential nodulation, it could also simply be what can be realistically achieved at Minnipa in a dry year on small plants.

In general, anything that affects the survival of applied rhizobia will in turn decrease nodulation. For example; application of pesticides (see article by Rathjen *et al*. in this book), delayed sowing of inoculated seed and conditions in the soil prior to germination. Further to this correct storage (as per manufacture recommendations) of inoculant prior to use is essential for maintaining high numbers of rhizobia.

References

ABARES, Australian Crop Report, 2015. Australian Government, Department Agriculture, Fisheries and Forestry.

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