THE BEST RETURN ON INVESTMENT: INOCULATING OR TOP-DRESSING PULSES?

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TAKE HOME MESSAGES

- Top-dressing pulses with nitrogen does not pay; inoculation does. Nitrogen top-dressing of pulses resulted in little or no net growth or yield benefit.
- Inoculating pulses is most effective if the soil is moist and if residual soil nitrogen and soil rhizobia populations are low.
- The current study indicated that a return on investment of up to $60 can be achieved from the inoculation of chickpeas in the absence of soil rhizobia.

KEY WORDS

Biomass, chickpeas, field peas, inoculation, nitrogen top-dressing, pulses, return on investment, rhizobia, yield.

BACKGROUND

From a growers' perspective, inoculating legumes during the haste and pressure of sowing is a job that most would avoid if they could. To determine whether inoculating legumes should be a priority, growers need to have a clear understanding of its true value. They need to know the costs and benefits of inoculating, the type of inoculant to use for each pulse type and under which conditions it is important.

Last year a question was raised about top-dressing legumes with nitrogen to enhance growth. While adding nitrogen (N) to a crop that fixes its own N would be expected to create nutrient use inefficiencies and cost money that could be better spent elsewhere, perhaps when inoculation failure occurred, this could be an option. This trial investigates the use of inoculation on field peas and chickpeas and looks at how it compares to top-dressing 50kg/ha urea.

The inoculation of legumes involves applying rhizobium bacteria to the seed. Following sowing, the rhizobia colonise the soil, invade root hairs and form nodules. Atmospheric nitrogen is fixed within the nodules and converted firstly into ammonia (NH_3) and then amino acids, which are subsequently exported to the rest of the plant to support growth (*Drew et al. 2012*).

The total amount of N fixed by a legume is primarily determined by its nitrogen fixation capacity and dry matter production (Peoples et al, 2009). The more biomass produced, the greater the amount of nitrogen fixed. As a general rule-of-thumb, about 20kg of shoot N may be fixed per tonne of shoot dry matter (DM) produced, provided there are adequate rhizobia present in the soil and no major constraints to nodulation. When nitrogen associated with the nodules and root biomass is included, total plant N fixed per tonne of dry matter production for field peas can be 30kg N/t shoot DM and 40kg N/t shoot DM by chickpeas (Unkovich et al, 2010).

AIM

To evaluate the effect and profitability of inoculation and/or nitrogen top-dressing on chickpeas and field peas.

METHOD

Location:	Watchupga East	
Replicates:	Five	
Sowing date:	4 June 2013	
Sowing rate:	95kg/ha	
Seeding equipment:	BCG parallelogram cone seeder (knife points, press wheels, 30cm row spacing)	
Crop types:	PBA Striker chickpeas and PBA Twilight field peas	
Inputs:	4 June	TriflurX® (1.5L/ha) + Weedmaster® DUO (2L/ha)
	4 June	Simazine 500® (550g/ha) and Balance® 750 WG (80g/ha) on chickpeas only.
	8 August	Select® (500mL/ha) + Verdict™ 520 (100mL/ha) + Hasten™ (1%)
	4 October	alpha-cypermethrin (300mL/ha)
	21 October	alpha-cypermethrin (300mL/ha)
Harvest:	9 December	

This trial was sown later than most crops in the region to avoid a potential plantback issue (Lontrel residue) at the site. No fertiliser applied during the season, other than the specific treatments. Just prior to sowing, top-soil (0-10cm) samples were collected to ascertain baseline soil rhizobia (analysed by Dr Elizabeth Drew using the SARDI methodology). The trial was rolled on July 26.

Inoculation occurred on the morning of sowing. Peas were treated with Peat Nodulaid® (group E) and chickpeas with Peat Nodulaid® (group N) (Table 1). P pickle T was also applied to seed a few days prior to sowing.

Early biomass cuts were collected on 7 August, before top-dressing with 23kg/ha nitrogen (50kg/ha urea). Immediately after top-dressing 5mm of rain fell at the site. NDVI measurements were collected on 28 August. Biomass cuts (peak biomass/early podding for peas and mid flowering for chickpeas) occurred on 16 September.

Table 1. Inoculation and nitrogen top-dressing treatments.

Crop type	Inoculation	Nitrogen top-dressing (kg N/ha)
Peas	group E	–
	group E	23
	–	–
	–	23
Chickpeas	group N	–
	group N	23
	–	–
	–	23

RESULTS AND INTERPRETATION

Soil nitrogen

Total available soil N (0-120cm) were relatively low at sowing (60kg N/ha). On the basis of previous research undertaken in Australia and elsewhere in the world, this level of soil nitrate would not be expected to have a great effect on legume nodulation or nitrogen fixation (Schwenke et al, 1998; Peoples et al, 2009).

Field peas

Though the last legume crop (failed vetch) was grown in the paddock in 2006 (seven years ago) high to medium populations of pea rhizobia were measured in the soil prior to sowing (920 pea rhizobia per gram of soil). Under these conditions, peas would have been expected to nodulate well at the site provided the pea rhizobia were effective. The effectiveness of the rhizobium was not determined in the current study.

There was no significant difference between NDVI (leaf greenness and/or ground cover), peak biomass (early podding) or grain yield in response to any of the inoculation or N fertiliser treatments (Table 2).

Table 2. Grain yield, biomass, NDVI treatment cost and return on investment of field peas.

Treatment	NDVI 26 August 2013	Peak biomass (t/ha) 16 September 2013	Yield (t/ha)	Income ($/ha)*	Treatment cost ($/ha)	Return on investment ($)
Nil inoculant + nil N	0.26	1.89	1.04	312	0	
Group E inoculant + nil N	0.29	1.79	1.08	324	4.5	2.7
Nil inoculant + 23kgN /ha	0.27	1.83	0.99	297	25	-0.6
Group E inoculant + 23kgN /ha	0.26	1.67	1.06	318	29.5	0.2
Sig. diff.	**NS**	**NS**	**NS**			
LSD (P=0.05)	**–**	**–**	**–**			
CV%	**13.8**	**28.8**	**15.4**			

*Field pea price = $300/tonne

Chickpeas

No resident chickpea rhizobia were detected and consequently an inoculation response was anticipated.

Early July biomass cuts taken prior to nitrogen top-dressing did not result in significant differences between chickpeas that were inoculated and those that were not. At the time, the chickpeas were small. It is possible that the rhizobium benefits had not yet been translated into biomass. It can take approximately six to eight weeks for inoculation effects to become apparent and chickpea growth in cool winter weather is often slow.

Significant treatment differences were observed between NDVI, early flowering biomass and yield. August NDVI and early flowering biomass results for both inoculation and top-dressed nitrogen treatments showed greater reflected leaf greenness and biomass than the zero nitrogen application, which was significantly less.

All inoculated chickpeas yielded more than those that were not inoculated. When the chickpeas were inoculated, a single application of fertiliser N did not result in improved grain yield. A small yield benefit was observed with a top-dressing of 23kg N/ha in the absence of inoculation.

A $60/ha return on investment was achieved from the inoculation only treatment, but when nitrogen fertiliser was also applied, the return was reduced to $8/ha. In the absence of rhizobia, one single $25/ha top-dressing of 23kg N/ha provided a small return of $4/ha. Future investigations could examine whether improved responses to fertiliser nitrogen might be achieved with either later top-dressing or split applications to better match plant growth requirements.

Table 3. Grain yield, biomass, NDVI treatment cost and return on investment of chickpeas.

Treatment	NDVI 26 August 2013	Early flowering biomass (t/ha) 16 September 2013	Yield (t/ha)	Income ($/ha)*	Treatment cost ($/ha)	Return on investment ($)
Nil inoculant + nil N	0.19[c]	0.38[b]	1.02[c]	408	0	
Group N inoculant + nil N	0.24[ab]	0.81[a]	1.70[a]	680	4.5	60
Nil inoculant + 23kg N/ha	0.22[b]	0.81[a]	1.26[b]	504	25	4
Group N inoculant + 23kg N/ha	0.26[a]	0.87[a]	1.61[a]	644	29.5	8
Sig. diff.						
Inoculation	P<0.001	P=0.002	P<0.001			
N	P=0.029	P=0.002	NS			
Inoculation x N	NS	P=0.009	P=0.008			
LSD (P=0.05)						
Inoculation	0.02	0.13	0.11			
N	0.02	0.13	–			
Inoculation x N	–	0.18	0.16			
CV%	7.8	18.5	8.2			

*Chickpea price=$400/tonne, N=$25/ha (urea @ $500/t divided by 0.46%N=$1.09/kgN x 23kg N/ha), Peat inoculant=$4.5/ha (Nodulaid @ $0.48/kg applied to seed sown at 95kg/ha).

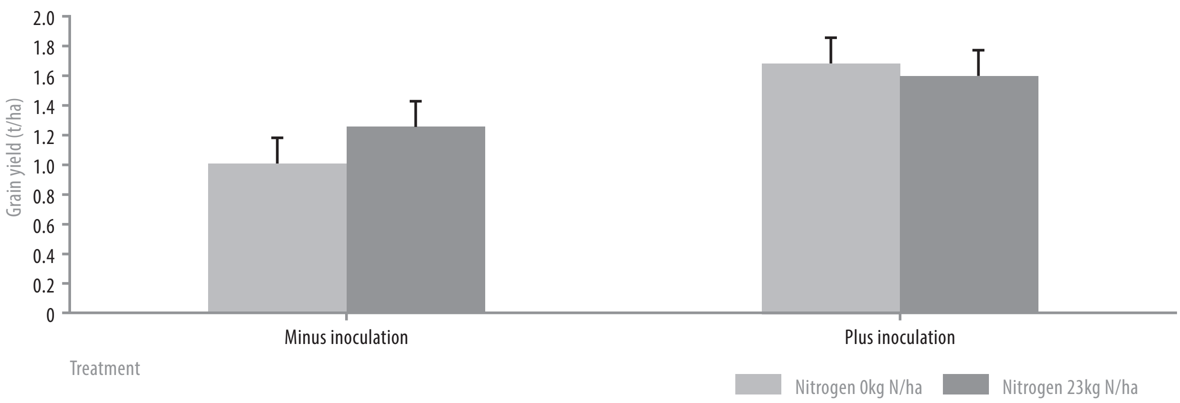

Figure 1. Chickpea yield comparisons for inoculation and nitrogen treatments. Stats: P=0.008, LSD 0.16t/ha, CV8.2%

COMMERCIAL PRACTICE

In this trial, determinations of resident populations of rhizobia proved to be useful for assessing whether inoculation was necessary or not. Unfortunately, this service is currently not available commercially. However, such testing could be advantageous to assist decision-making by growers and their advisors.

It is important to know the paddock's soil nitrogen reserve. Soil nitrate is an inhibitor of legume nodulation and nitrogen fixation. If soil nitrogen is too high, effective nodulation from native or inoculated rhizobia is unlikely.

Knowledge of which rhizobia group nodulates each pulse type is also important. In this trial, different levels of group E (pea) rhizobia (medium to high levels) and group N (chickpea) rhizobia (none detected) were tested. Generally group N, chickpea rhizobia is less prevalent in the soil than group E rhizobia. The absence of chickpea-nodulating rhizobia in the paddock emphasised the importance of inoculating chickpeas.

When populations of soil rhizobia are low, excellent nodulation responses can occur with inoculation and returns on investment can be substantial. In this trial, inoculating chickpeas provided a $60/ha return on investment.

Field peas sown into soil with existing, medium to high, group E rhizobium may provide only small or zero return from inoculation.

In the absence of soil rhizobia, a single 25kg N/ha top-dressing with nitrogen fertiliser provided only a small compensation for not inoculating legumes. The N fertiliser top-dressing is likely to have reduced the amount of nitrogen fixed from the atmosphere where sufficient rhizobia were either provided, or already present in the soil (plant samples are currently being analysed to quantify the effect). Peat inoculant is a low cost input and can be considered cheap insurance, even given the stresses of sowing.

Peat inoculant ($4.5/ha) is generally thought to be more effective than granular inoculant in conditions where soil is moist (Denton et al, 2009). But, if dry sowing, granular inoculant should be used. At 12 inch row spacing, this costs approximately $17.4/ha.

Researchers suggest that pulse seed should be inoculated if the break between legume crops with a similar rhizobia group is four years or more. In the case of this trial, the paddock was last sown to a vetch (group E) in 2006, seven years ago; adequate group E rhizobia persisted for this period of time.

Inoculant is effective if soil is moist, and both soil nitrogen and soil rhizobia populations are low. The benefits of inoculation outweigh the time constraints of applying inoculant at sowing.

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