Liquid trace elements at sowing reduced nodulation and yield in chickpea

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Key Messages

- Trace elements applied as a liquid is toxic to inoculant both when combined in solution and applied separately on the seed
- Chickpea plants with trace elements applied in-furrow had lower nodulation and yield than plants sown without trace elements
- Liquid trace elements were applied in-furrow either with inoculated seed, or as a combined peat inoculant plus trace elements mixture

Background

The aim of this trial was to determine the compatibility of rhizobia with liquid trace element fertiliser. In some cases farmers would like to apply amendments at sowing (fertilisers, fungicides, pesticides) but with little knowledge as to the effect of these chemicals on the inoculant. Pulses such as chickpeas have a high nutritional requirement especially for trace elements which have known toxicity to rhizobia *in vitro*. Inoculation of chickpeas is vital to ensure adequate nodulation for growth and yield, yet little is known about the effect of fertiliser applications on rhizobial survival both on the seed and in-furrow at sowing

Prior laboratory research showed that common commercial trace element solutions are highly toxic to rhizobia. The toxicity can be related to either low pH, as well as direct toxicity of the trace, or both (Ballard et al 2017). There has been some evidence that farmers mix trace element solutions with inoculant at sowing time to reduce double handling, which can have catastrophic consequences to the survival of the rhizobia (Ballard et al 2017). To determine the toxic effect of the trace element liquid fertiliser, we applied the liquid separately alongside the inoculated seed and together with the inoculant infused in the trace element solution.

About the trial

The trial was designed to follow farmer practice of applying liquid trace elements in the furrow at seeding. We tested the effect of a trace element solution based on commercial rates (Cu, Zn, Mn, Mo) with the peat inoculant applied on the seed and in the liquid fertiliser (tea-bag method). The trace element solution was devised from a commercial formulation (Table 1).

The trial was conducted at Angas Valley in the SA mallee in 2020 on a sandy loam soil (Table 1). Chickpeas were sown in late May with peat-based seed inoculant, with or without trace elements sprayed into the furrow, or with the inoculant supplied as a liquid sprayed into the furrow. The liquid inoculant was applied in water or as a trace element solution, infused with peat inoculant. This was achieved by placing the peat inoculant into a nylon bag in the water/trace element solution to allow the rhizobia to diffuse but not the fibrous component (‘teabag’ method). Nil inoculant and nil fertiliser plots were included as controls. Each treatment was replicated three times. Plants were sampled (12 plants/plot) in August to rate nodulation (Corbin et al 1977), with biomass (shoot dry weight) and yield also measured.

Table 1. *Summary of chickpea inoculant and liquid trace element trial conducted at Angas Valley 2020*

Inoculant	Trace elements	Trace Element Solution / ha
Nil	-	$CuSO_4$ 1 kg
Peat liquid only in furrow	-	$ZnSO_4$ 2.5 kg
Peat on seed only	-	$MnSO_4$ 3.5 kg
Peat on seed	+	Na_2MoO_4 0.06 kg
Peat liquid + TE in furrow	+	

Results & Discussion

The 2020 season at Angas Valley was slightly below average with a dry period May to July but receiving a much needed rainfall in early August. In general, the dry period after sowing was also colder than average, which provided difficult conditions for the establishment and early nodulation of the chickpeas. Although average nodule rating was lower than desirable, the shoot biomass and yield were higher than expected despite the slow early growth.

Figure 1 shows the average nodule rating (12 plants per plot) in late August. The average rating was low with 2.5 considered adequate nodulation for chickpea (Corbin et al 1977), which may have been due to the cold conditions after sowing and the time when the plants initiate nodulation. Although there was no significant difference between the nil and peat only inoculated plants, there was a significant decrease in nodule rating in the plants which inoculated with peat infused into a trace element solution. There was also a decrease in nodule rating, although non-significant, with the plants inoculated with peat on the seed and trace elements applied into the furrow.

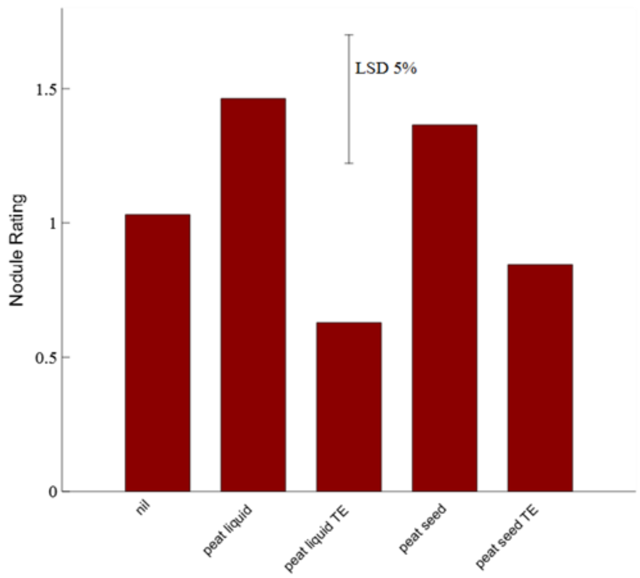

Figure 1. *Average nodule rating (0-5 scale) of plants with different inoculation and trace element treatments (nil = no inoculation and trace elements, peat liquid = peat inoculant infused into water and sprayed in-furrow, peat liquid TE = peat inoculant infused into trace element solution and sprayed in-furrow, peat seed TE = peat inoculated onto seed and trace elements sprayed in-furrow).*

Table 2 shows the biomass and yield data, which is also displayed in Figure 2. There were no significant differences in biomass between treatments, but there was a significant decrease in the yield in the liquid trace element treatment, even though the inoculant was separated from the trace elements by coating onto the seed.

***Table 2.** Yield and shoot biomass of chickpeas grown at Angas Valley in 2020.*

Inoculant	Trace Elements	Grain yield (t/ha)	Shoot biomass (g plant/plot)
Nil	-	0.9ab	64.6
Peat liquid only	-	1.1a	106
Peat on seed only	-	1.1a	92
Peat on seed	+	0.6bc	84
Peat liquid	+	0.8ab	82.6
LSD 5%		0.3	NS

Figure 2 shows the similarity between the nodulation and yield data. The nodule rating score closely followed yield, where treatments with peat and trace elements sprayed into the furrow had a lower yield (and nodule rating) than when the peat was coated onto the seed only. Yield was reduced, although not significantly, when the peat inoculant was infused into the trace element solution. This was surprising because the population of rhizobia recovered from the peat plus trace element solution was 30% lower than the viable population of rhizobia recovered from the peat liquid without trace elements (data not shown). Although there was no history of chickpea grown at this site, there was some nodulation in the nil inoculant treatment. The fixation of N due to background rhizobia may have contributed to the yield being comparable with the inoculated treatments (Figure 2). N fixation data is currently being processed to address this possibility. The background rhizobia may also be an explanation for the higher than expected nodule rating in the peat plus trace element treatment (Figure 1).

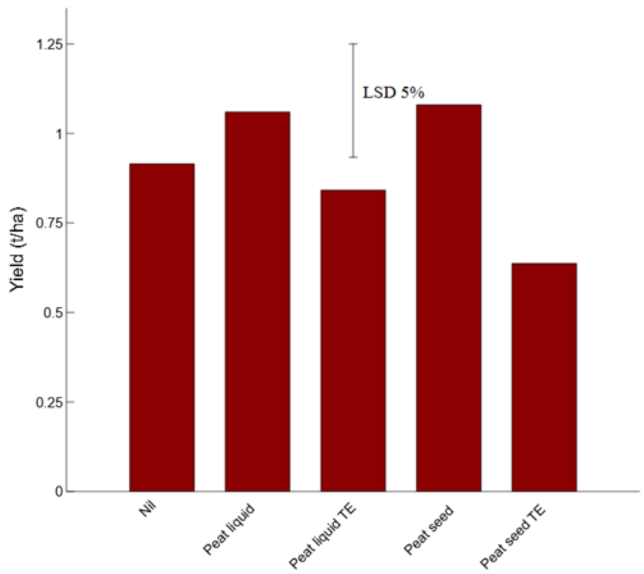

***Figure 2.** Average yield of chickpeas with different inoculation and trace element treatments (nil = no inoculation and trace elements, peat liquid = peat inoculant infused into water and sprayed in-furrow, peat liquid TE = peat inoculant infused into trace element solution and sprayed in-furrow, peat seed TE = peat inoculated onto seed and trace elements sprayed in-furrow).*

Implications for commercial practice

Liquid trace elements applied at sowing of chickpeas can have a detrimental effect on the inoculant, nodulation and even yield. It is advisable to separate the inoculant from toxic amendments such as trace elements at sowing. These results show that separation of liquid trace elements does not necessarily prevent reductions in nodulation and yield. Rhizobia are highly sensitive to both low pH (< pH 5) and trace elements (such as Zn and Cu), and to improve inoculation and nodulation, we suggest that liquid trace element fertilisers are not applied in furrow at sowing of chickpeas, and could be applied as a foliar spray instead.

Further work in this area investigating other pulse crops and different fertilisers and trace elements combined with inoculants may be undertaken in the future.

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