INOCULANT AND SEED TREATMENT

FACT SHEET

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Compatibility of rhizobia inoculants with common chemical seed treatments

KEY POINTS

- Mixing rhizobia inoculants with some fungicides, insecticides, fertilisers or trace elements can interfere with nodulation and nitrogen (N) fixation, so it is good practice to separate the rhizobia from the chemical.
- When a pesticide seed treatment is required, opting for a granular inoculant or freeze-dried in-furrow inoculum will reduce the direct exposure of rhizobia to potentially harmful chemicals.
- If there is no alternative to inoculating fungicide-treated seed, always apply the fungicide first and allow it to dry. Sow the seed into moist soil as soon as possible after applying the inoculant

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Mixing inoculant with legume seed treatments or soil additives at seeding requires careful planning to ensure chemical toxicity does not affect the rhizobia and subsequent nodulation.

Introduction

Planting legumes as part of a cropping rotation provides growers with valuable rotational benefits, including the fixation of atmospheric N. Depending on the legume type, the amount of N fixed can exceed 100 kg/ha for utilisation by the following cereal crops.

The process by which legumes fix atmospheric N relies on a symbiotic relationship with nitrogen-fixing soil bacteria called rhizobia. The rhizobia form nodules on the plants roots where the N fixation takes place.

Different legumes require species specific rhizobia (Table 1). Legume crops are introduced to Australia and as such our soils do not naturally contain the correct rhizobia species. Thus, we need to introduce and maintain adequate soil levels of the required rhizobia through the inoculation of seed when planting legumes.

It is typically considered best practice to inoculate all legume seed especially if it has been several years since the legume crop was last planted and in soil types that are considered to be detrimental to rhizobia survival (e.g. acidic soils).

However, many of the seed treatments and fertilizers used to optimise germination and early growth in Australian cropping systems are hostile or even toxic to rhizobia.

Fungicides

Treating seed with fungicide before sowing is a common method of protecting seedlings from fungal pathogens.

While some fungicides are toxic to rhizobia, if these toxic effects are avoided, seed applied fungicides can increase plant health and root growth which in turn can benefit nodulation and N fixation. However, where the inoculants applied to seed come in direct contact with the fungicide, toxicity issues can occur.

Rhizobial survival and the subsequent success of the legume crop will depend on the toxicity of the applied fungicide to rhizobia and the duration the rhizobia spend in contact with the chemical.

P Level 4, 4 National Circuit, Barton ACT 2600 | PO Box 5367, Kingston ACT 2604
T +61 2 6166 4500 **F** +61 2 6166 4599 **E** grdc@grdc.com.au

TABLE 1. Examples of legume crop and matching rhizobia species.

COMMON LEGUME AND RHIZOBIA PAIRINGS		
Legume crop	**Inoculation Group(s)**	**Rhizobia**
Lupin, serradella	G and S	*Bradyrhizobium* spp.
Soybean	H	*Bradyrhizobium japonicum*
Clovers	B and C	*Rhizobium leguminosarum* bv. *trifolii*
Field pea, faba bean, lentil, vetch	E and F	*Rhizobium leguminosarum* bv. *viciae*
Chickpea	N	*Mesorhizobium ciceri*
Medics	AM and AL	*Sinorhizobium* spp.

In a 2016 study in Victoria, faba bean seeds were treated with the fungicide P-Pickel T® (PPT), which contains thiram and thiabendazole, before being inoculated with rhizobia as a peat slurry. Compared to unpickled seed, the PPT seed treatment caused a notable reduction in N fixation and grain yield in the resulting crop (Figure 1).

However, the detrimental effects of PPT on rhizobia survival and nodulation (when rhizobia are applied directly to seed) can be overcome by applying rhizobia as a granular inoculant, effectively separating the rhizobia from the seed applied chemical.

This was demonstrated in a field trial with chickpea at Mallala, South Australia in 2019 (Figure 2).

Laboratory studies have also shown fungicides containing high levels of metalaxyl or metalaxyl-M have an inhibitory effect on rhizobia and nodulation, and so applying a granular inoculant or liquid or slurry inoculant in furrow is recommended when these fungicides are applied to seed.

Insecticides

The diversity of insecticide chemistries that can be applied to seed means there is a range of potential effects on rhizobia co-applied as inoculant.

For example, bendiocarb and permethrin, which may be applied to protect seed from ant attack, are currently considered safe for rhizobia. However, limited trials have indicated there may be some reduction in nodulation when these compounds are applied.

Imidacloprid is considered safe to use with rhizobia.

A study by University of Adelaide researchers (Rathjen et al. 2020) found that the imidacloprid insecticide Gaucho® did not significantly reduce field pea nodulation when compared to the control treatment (water) in laboratory and glasshouse tests.

Conversely, insecticides containing dimethoate are considered incompatible with liquid peat slurry applied to seed as well as freeze-dried rhizobia inoculants.

Fertilisers and trace elements

Some common fertilisers such as mono-ammonium phosphate (MAP) produce acidic conditions which may be toxic to rhizobia, and trace element preparations can also be highly toxic to rhizobia.

With the exception of bentonite clay rhizobia granules, the mixing of fertilisers and inoculant granules is not recommended.

A short period of direct contact between rhizobia and trace elements can reduce the survival of rhizobia and affect nodulation and N fixing rates.

Zinc, manganese and molybdenum in the form of sodium molybdate are toxic to rhizobia. Even traces of these products remaining in equipment is likely to lead to nodulation failure. As a result, all tanks and lines must be thoroughly cleaned before being used to apply in-furrow inoculum.

Molybdenum is required for nodulation and N fixation by legumes, and

FIGURE 1. Effect of pesticide application to seed on N fixation (left axis, columns) and grain yield (right axis, circles) of faba bean (PBA Samira) inoculated with Group F rhizobia (WSM1455) at Ballyrogan (site pH(Ca) = 4.6) Victoria, 2016. Different letters above columns and circles indicate significant treatment differences at P<0.05. (Farquharson et al, via GRDC Update paper *Best options for optimal performance from rhizobial inoculants*.)

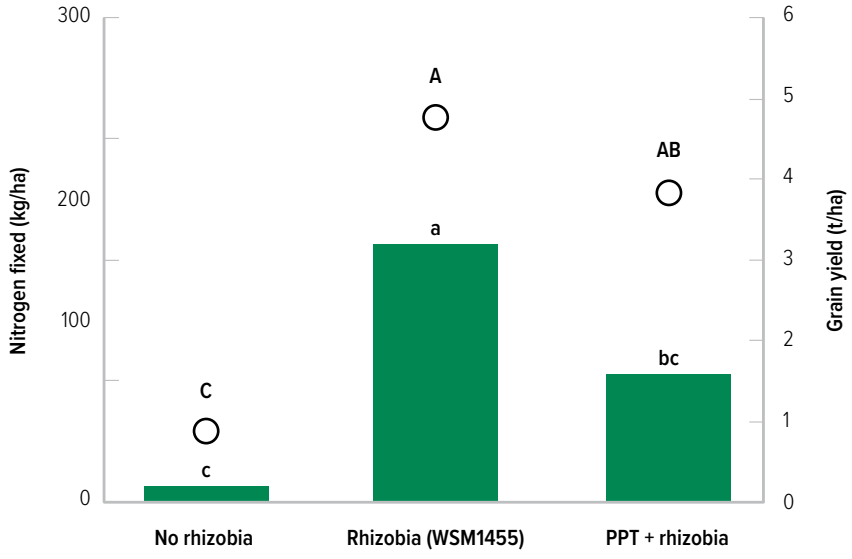

Photo: Belinda Cay, AgCommunicators.

The inoculated seed ready for sowing. As a rule, legume seed should be sown as soon as possible after inoculation. (See Table 2.)

TABLE 2. Compatibility (seed inoculation) of different rhizobia groups when mixed with seed-applied fungicides and insecticides.

Inoculant group / Crop	Pesticide type	Planting window of inoculated seed
E – Field pea, Vetch	Thiram (360g/L) + Thiabendazole (200g/L)	Not compatible
	Imidacloprid (600g/L)	24 hours
F – Faba bean, Lentil	Thiram (360g/L) + Thiabendazole (200g/L)	Not compatible
	Thiram (600g/L)	Not compatible
	Imidacloprid (600g/L)	24 hours
G – Lupin	Thiram	Not compatible
	Iprodione (250g/L)	6 hours
H – Soybean	Not compatible with seed dressings	
N – Chickpea	Thiram (360g/L) + Thiabendazole (200g/L)	Not compatible
	Thiram (600g/L)	Not compatible
	Metaxalyl-M (350g/L)	6 hours
P – Peanut	Not compatible with seed dressings	

Information sourced from commercial product information guides (BASF and Novozymes) and research data (Rathjen et al. 2020). All pesticide use must comply with APVMA registrations and label directions.

FIGURE 2. Nodulation of chickpea at Mallala, SA in 2019 using three different inoculant types with and without seed-applied P-Pickel T fungicide (PPT; used at label rate). Inoculant was applied as freeze dried (FD) inoculant (EzyRhiz), TagTeam granular inoculant (Granular) and New Edge Microbials peat slurry inoculant (Peat). Seed was planted either immediately (0h) or 24 hours (24h) after inoculant application. Small plot (3 reps) trial. Nodule rating 0 to 5 scale. (Rathjen et al, University of Adelaide, unpublished data).

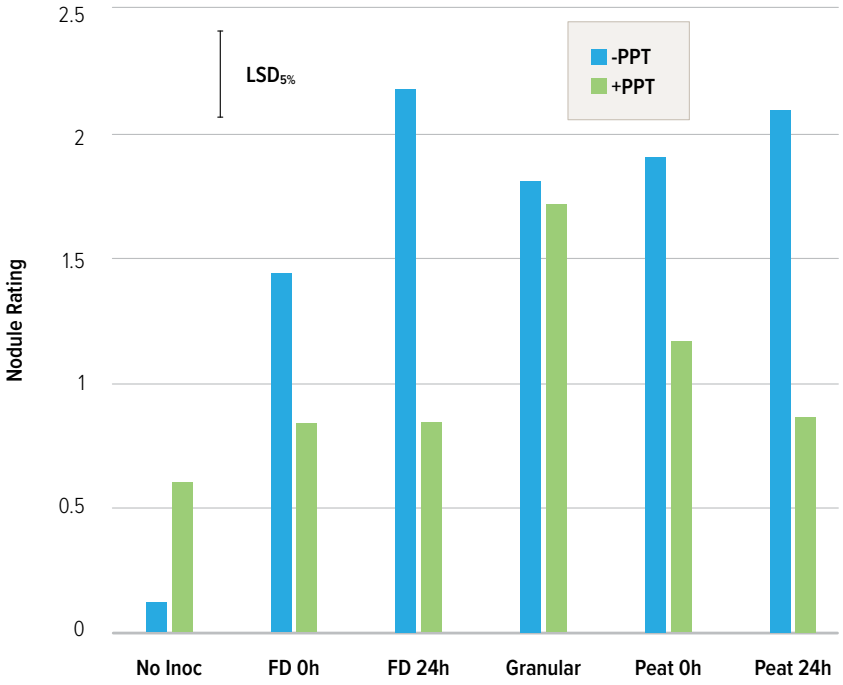

Photo: Ashlea Webster, AIRG, NSW DPI.

Granular inoculants from left to right: clay granules (attapulgite) coated with peat, clay (bentonite) with rhizobia incorporated and prilled peat.

molybdenum availability can be inhibited by soil acidification. If spreading a molybdenum compound on the paddock is not an option, molybdenum trioxide (66 per cent Mo) or ammonium molybdate (54 per cent Mo) can be safely used as a seed application.

Herbicides and herbicide residues

In general, registered herbicides applied to legume crops have no detrimental effect on the rhizobia survival, nodulation or N fixation. Herbicide carry-over from previous crops or pastures can cause issues, mainly for the host legume growth.

Some herbicide residues and in-crop applications, particularly those in group B (imidazolinones and sulfonylureas) and group I (e.g. clopryalid) can significantly reduce the growth, N fixation and yield of some legume crops. This is mainly due to the susceptibility of the plant to the herbicide.

It is essential to observe registered label rates and plant-back requirements for residual herbicides.

In low rainfall cropping zones, particularly those with alkaline soils, many herbicide residues break down slowly and may directly impact susceptible legume plants and the rhizobia.

Protect rhizobia from pesticides

Rhizobia are living organisms and can be sensitive to seed pesticide treatments, fertilisers and trace elements applied at sowing.

If coating fungicides onto seed, especially those that are toxic to rhizobia such as thiram or metalaxyl, always apply the fungicide first and allow it to fully dry. Then apply the inoculum immediately prior to sowing the seed into moist soil. Alternatively, consider inoculation with a granular formulation, or in-furrow use of a peat slurry or freeze-dried product. This will help minimise contact between the chemical and the rhizobia in the inoculant.

Never tank mix a slurry or liquid inoculant with seed dressings, liquid fertilisers, trace elements or organic preparations.

Avoid mixing fertilisers and inoculant granules, with the exception of bentonite rhizobia granules.

As a general rule, it is important to minimise the amount of time rhizobia are directly exposed to in-compatible seed treatments by applying inoculum to seed last and, ideally, not more than six hours before sowing.

Rhizobia applied to seed will remain in contact with other seed treatments for longer when sown into dry soils. The extended exposure and dry conditions are both sources of stress for rhizobia and can also impact rhizobia survival, resulting in sub-optimal nodulation. A doubled rate of inoculation can be considered in these situations, to help increase the likelihood of successful nodulation and N fixation.

MORE INFORMATION

Maarten Ryder
University of Adelaide
0409 696 360
maarten.ryder@adelaide.edu.au

Liz Farquharson
Liz.farquharson@sa.gov.au

Ross Ballard
Department of Primary Industries and Regions, South Australian Research and Development Institute (PIRSA-SARDI)
Ross.ballard@sa.gov.au

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FREQUENTLY ASKED QUESTIONS

Is it safe to mix inoculant with fertilisers?

Most types of direct mixing of inoculant and fertilisers or other soil amendments should be avoided.

Rhizobia are highly sensitive to acidic solutions, including those formed when a fertiliser (e.g superphosphate, triple super, MAP) encounters moisture. This can occur when the fertiliser encounters inoculant peat slurry or moisture in the soil. The resulting solution can kill the rhizobia through desiccation and acidity.

Some essential trace elements, including zinc, manganese and sodium molybdate are also toxic if mixed directly with rhizobia.

Which inoculation method should I use if I need to apply other seed treatments?

Generally, inoculant should be applied last to the seed, after the pesticide treatment has been applied and allowed to dry. Once inoculated seed should be sown as soon as possible afterwards. This minimises the amount of time the rhizobia will be in direct contact with any harmful chemistry in the other seed treatments.

Aim to minimise any contact between rhizobia and toxic seed treatments.
If an incompatible pesticide needs to be applied to the seed, using granular inoculant may be preferable to applying a slurry or liquid rhizobial treatment to seed.

Doubling the inoculant rate applied to seed may also be useful for helping rhizobia overcome a moderate level of seed treatment toxicity or inhospitable soil conditions.

Is inoculation always required?

In paddocks where the same legume crop has been grown in the past four years, there may be a residual rhizobia population that will support sufficient nodulation in a new crop.

However, rhizobia require hospitable soil conditions to survive between seasons and rotations. The GRDC Back Pocket Guide to Inoculating Legumes contains useful information on the conditions that favour rhizobia for specific legume crops.

New rapid soil tests can measure paddock rhizobia populations to better inform decisions on the need to inoculate.

Researchers at the South Australian Research and Development Institute have developed a PREDICTA® soil test for the rhizobia that nodulate field pea, faba bean, lentil and vetch. This test was made commercially available in South Australia and Victoria in 2021, with national release planned for 2022. A limited release of tests for chickpea and lupin is also planned for 2022.

USEFUL RESOURCES

GRDC Inoculating Legumes: Practice and Science
grdc.com.au/resources-and-publications/all-publications/publications/2022/inoculating-legumes-practice-and-science/

GRDC Back Pocket Guide - Inoculating Legumes
grdc.com.au/GRDC-BPG-InoculatingLegumes

GRDC Paddock Practices - 10 dos and don'ts when inoculating legumes
grdc.com.au/news-and-media/ news-and-media-releases/south/2020/april/paddock-practices-10-dos-anddonts-when-inoculating-legumes

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