

Inoculation Technologies to Improve the Nodulation of Lupins and other Grain Legumes in South-eastern Australia



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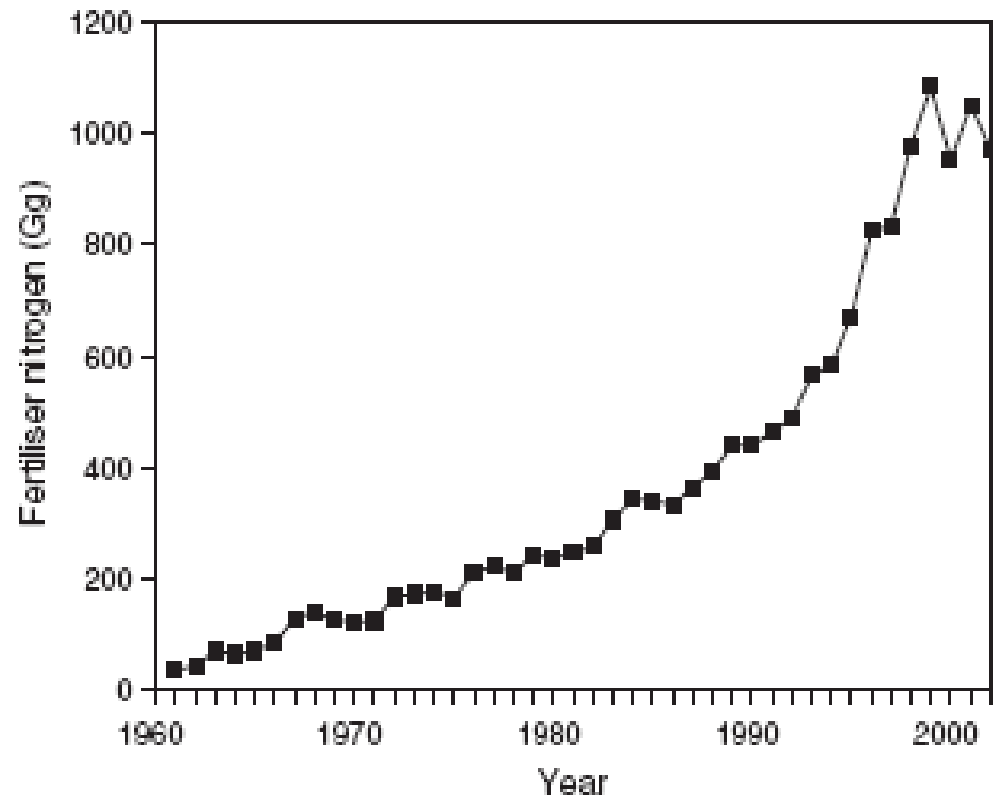
Outline

- The importance of legumes to farming systems
- Inoculant types in the Australian system
- Efficacy of liquid and granular inoculants
- Potential advantages of soil-applied inoculants

Australian agriculture is highly reliant on nitrogen inputs

Nitrogen fertilisers - the single most energy expensive input in agriculture

accounts for 35-68% of total on-farm energy use



Energy Efficiency of Fertiliser vs Legume N



Energy intensive
30 GJ t⁻¹ NH₃
4 kg CO₂ emitted / kg
N produced



Photosynthetically-
driven N fertiliser
Effectively no CO₂
emission

N provided by lupins

Crop type	Mean N balance (kg N/ha)	Range (kg N/ha)	Ref
Lupin	88	70-107	Evans 2001
Lupin	78	(-29) -247	Evans 1987, 1989
Lupin	97	174-177	Rochester 1998
Lupin	65	32 - 96	Unkovich 1994

- In addition, 30% of Total plant N is BG at harvest

Peat Inoculants



- Industry standard for Australia
- High quality
- $>10^9$ cells g^{-1} peat
- Applied as a slurry or a liquid

Granular inoculants



- Introduced into the Australian market for ~5 years
- Carriers: peat, or clays (usually bentonite, attapulgite)
- **Non-sterile** formulations (unlike peat slurries)

Freeze-dried inoculants

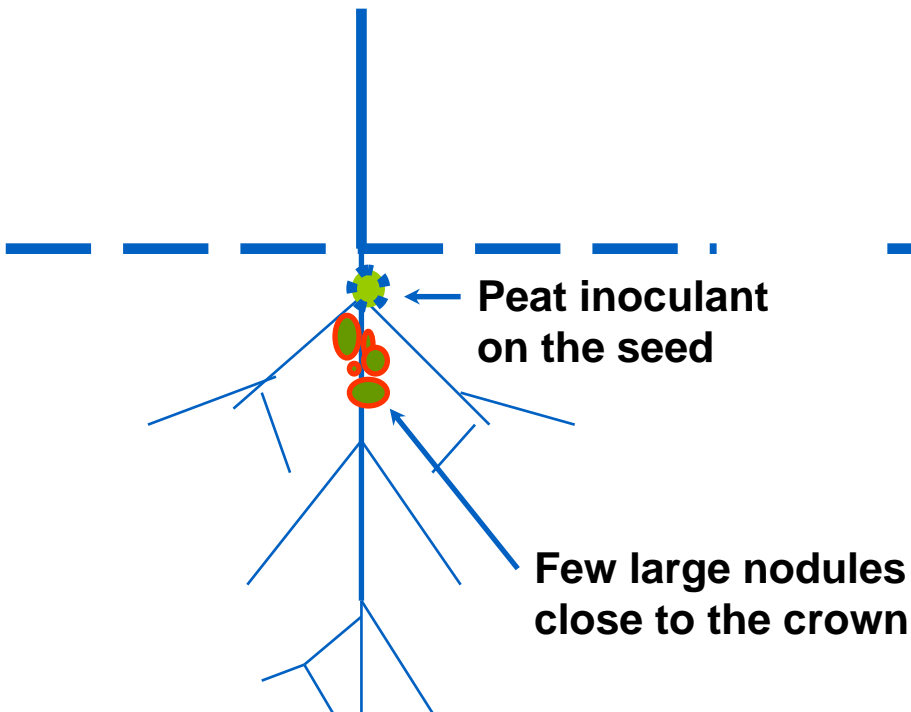


Applied as:
1) slurry to
seed, or
2) liquid into
furrows

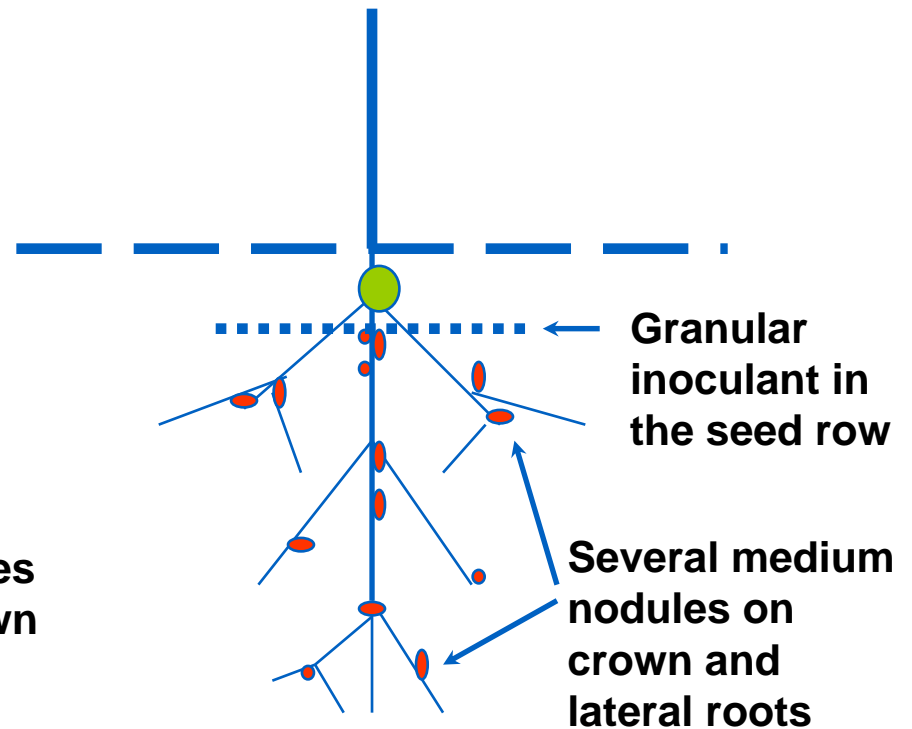
How do granular and liquid inoculants differ to peat slurries?

- Peat slurry inoculants are applied to SEED
- Granules and liquid inoculants are applied to SOIL
- Soil inoculation:
 1. Avoids incompatibility with seed toxins (fungicides, insecticides)
 2. Avoids the need to inoculate seed
 3. No time dependency when unfavourable conditions disrupt sowing
 4. Potential for dry sowing conditions

Seed inoculation



Soil inoculation



Chickpeas (Kyei-Boahen et al., 2001)

Treatment	Nodule dry weight (mg/plant)		
	Crown	Lateral	Total
Control	0.0	3.0	3.0
Liquid	9.5	16.0	25.5
Peat	193.3	70.8	264.0
Granular	80.3	163.0	243.3

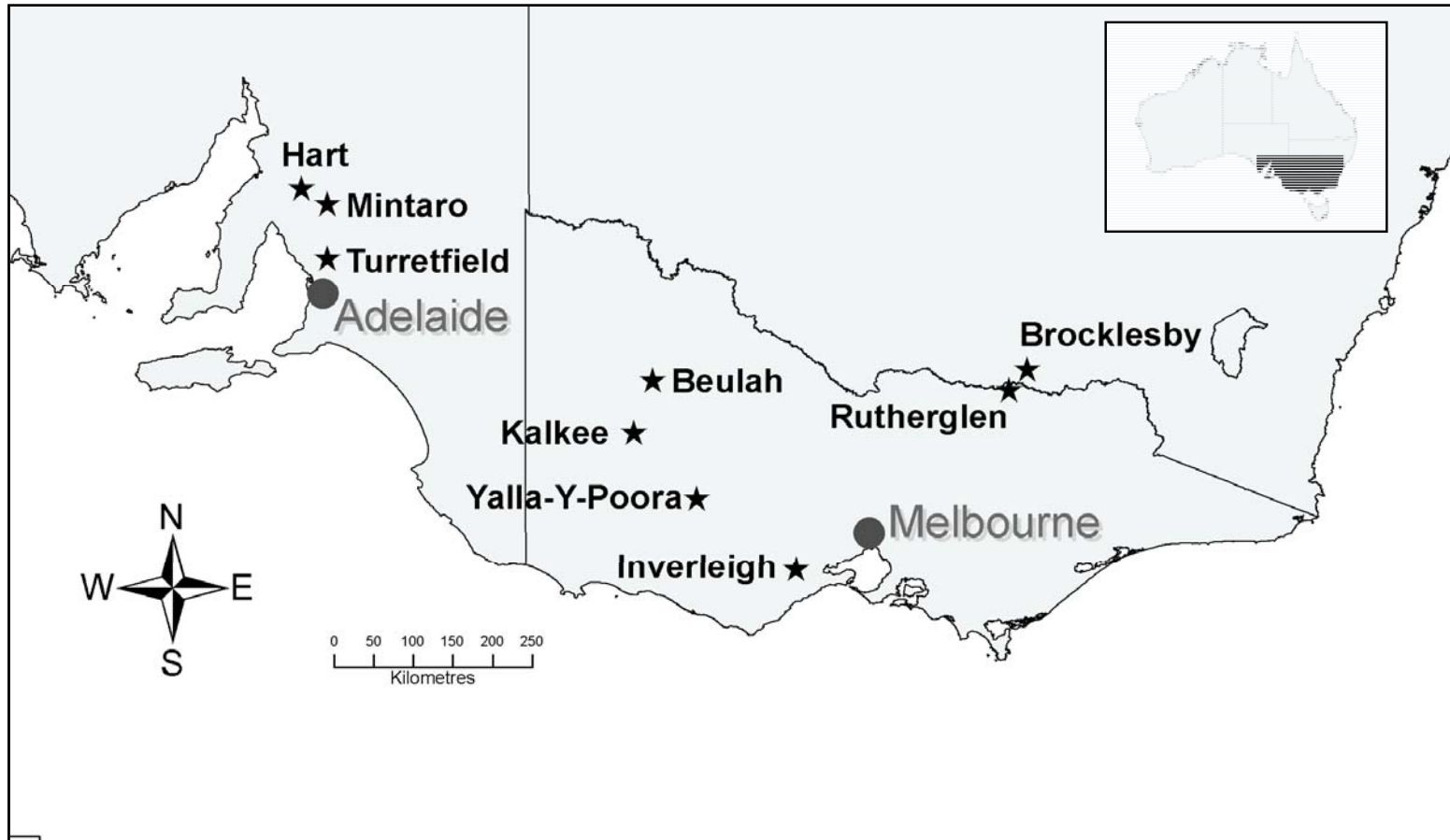
Chickpeas (Kyei-Boahen et al., 2001)

Treatment	%Ndfa	Grain yield (t/ha)
Control	17.2	1.22
Liquid	19.9	1.52
Peat	49.1	1.81
Granular	56.9	1.81

What is the efficacy of granular and liquid inoculants in Australia?

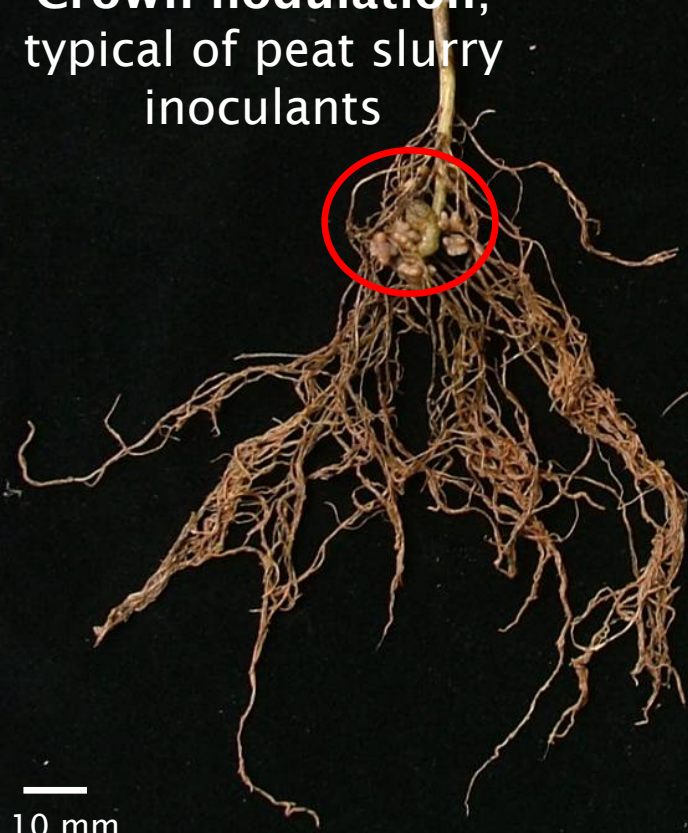
- 37 experiments over 5 years in Vic, SA and southern NSW
- Efficacy of granular and liquid inoculants tested
- Lupins, faba beans, peas, chickpeas and lentils

Site distribution

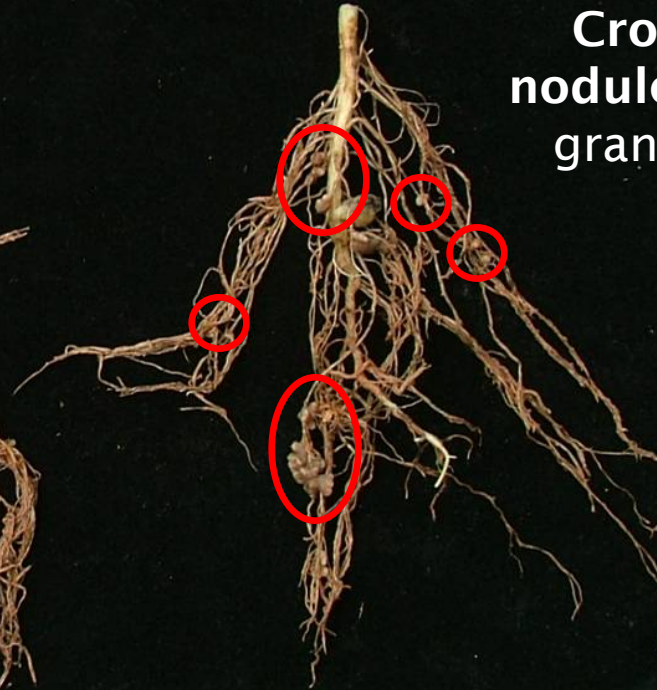


What difference does soil inoculation make?

Crown nodulation,
typical of peat slurry
inoculants

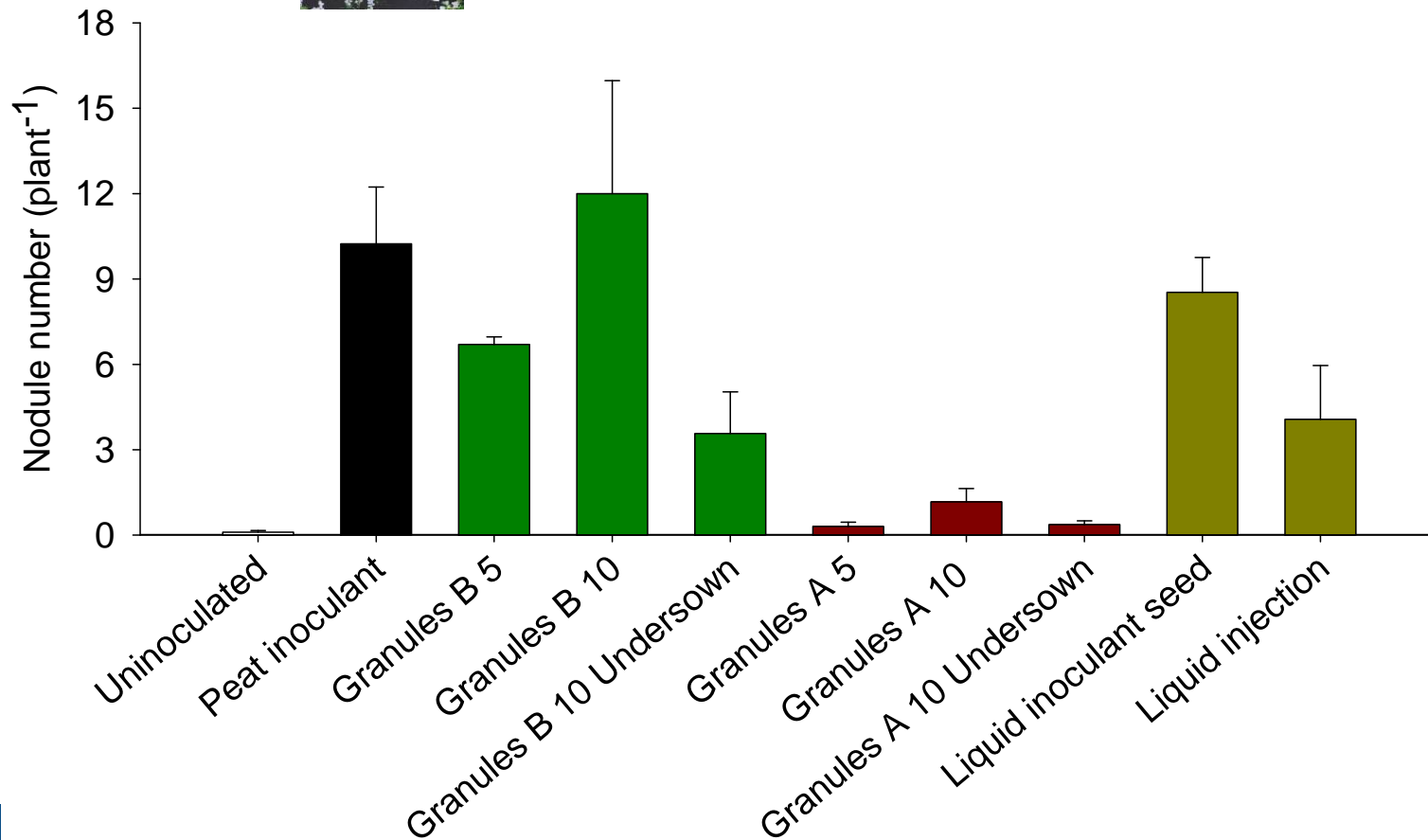


**Crown and Deep
nodules** from effective
granular and liquid
inoculants

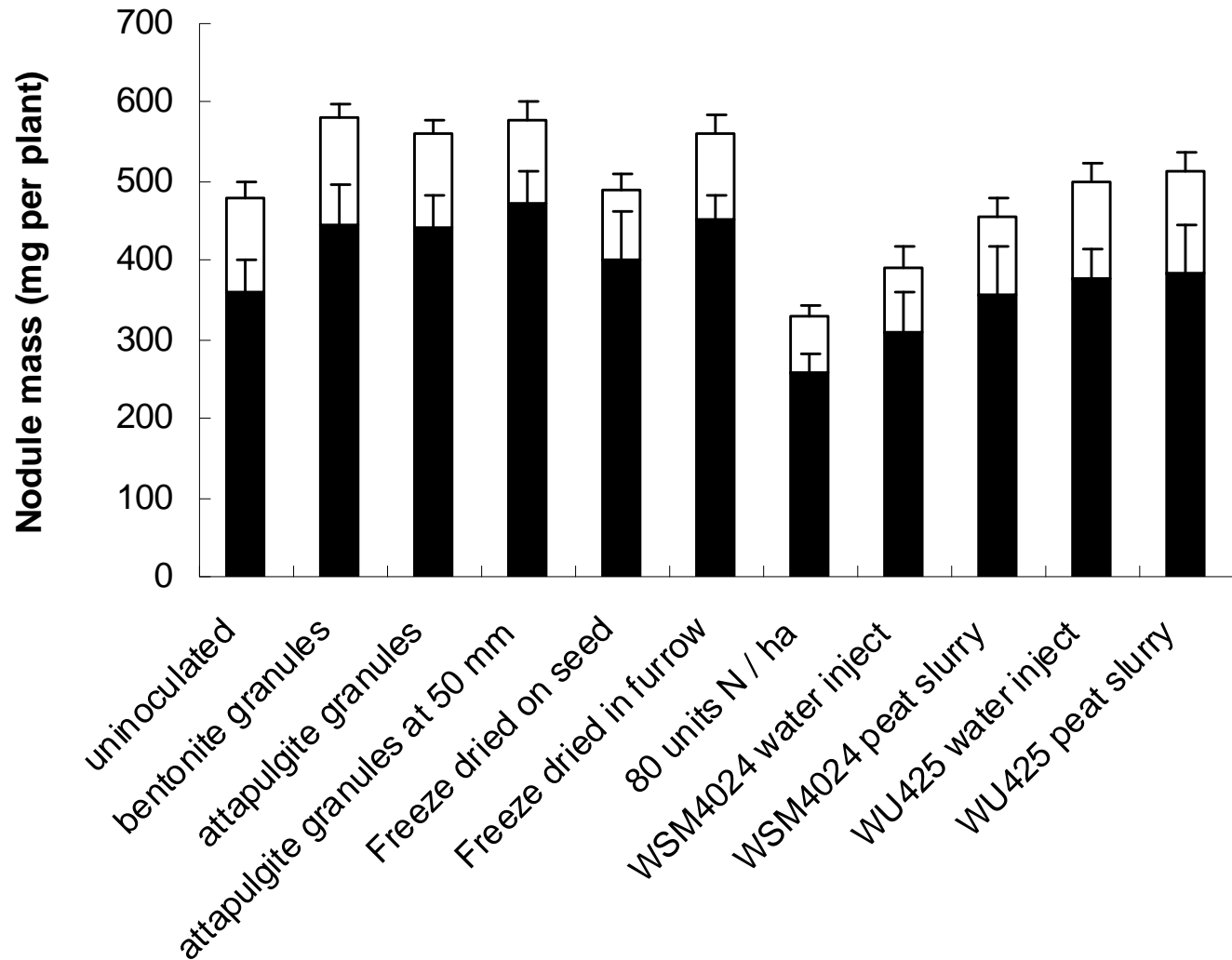


10 mm

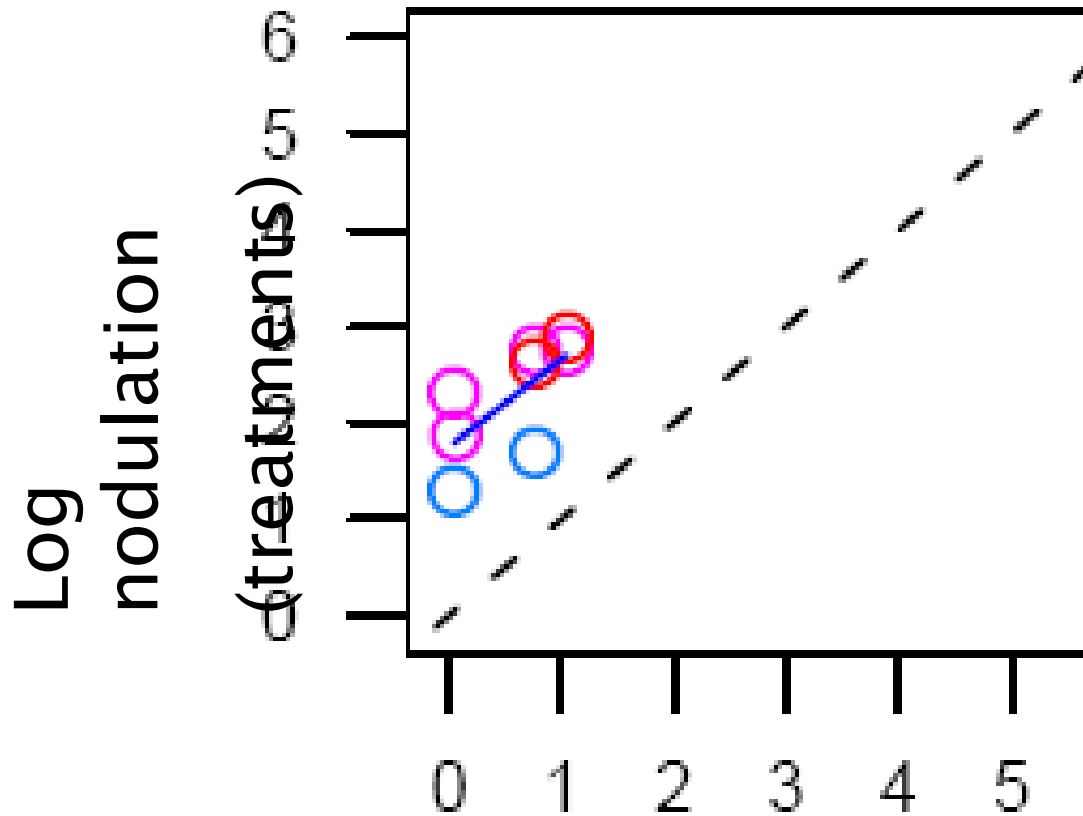
Nodule number



Poorly responsive sites



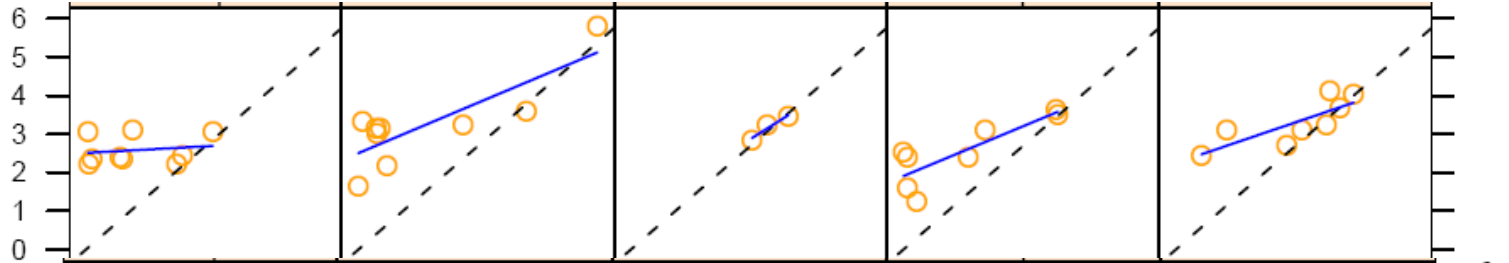
Response of Inoculants



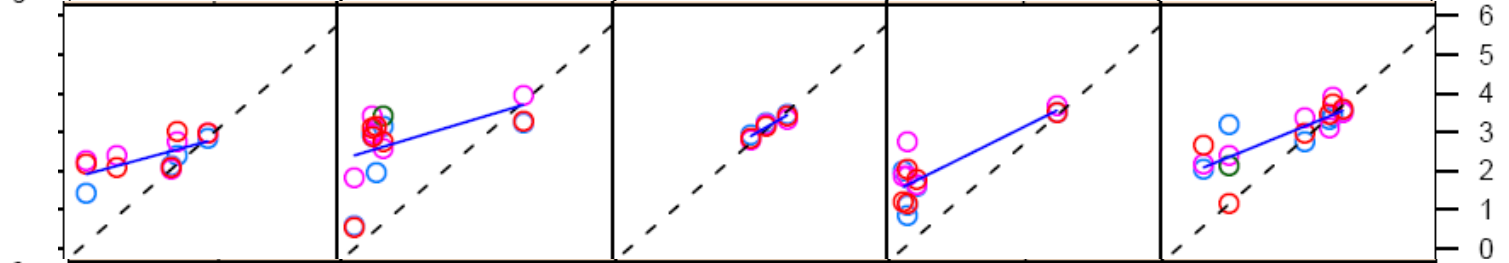
Log background nodulation
(nodulation by uninoculated

Chickpea Faba bean Lentil Lupin Field pea

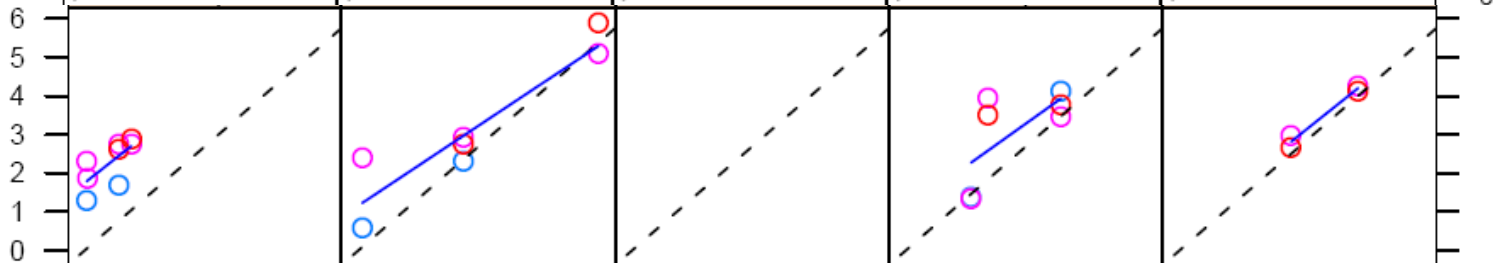
Peat slurry



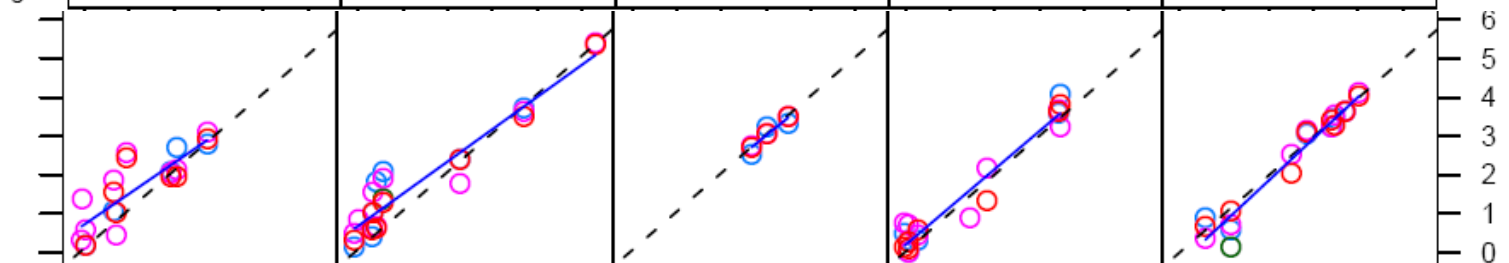
Peat granules



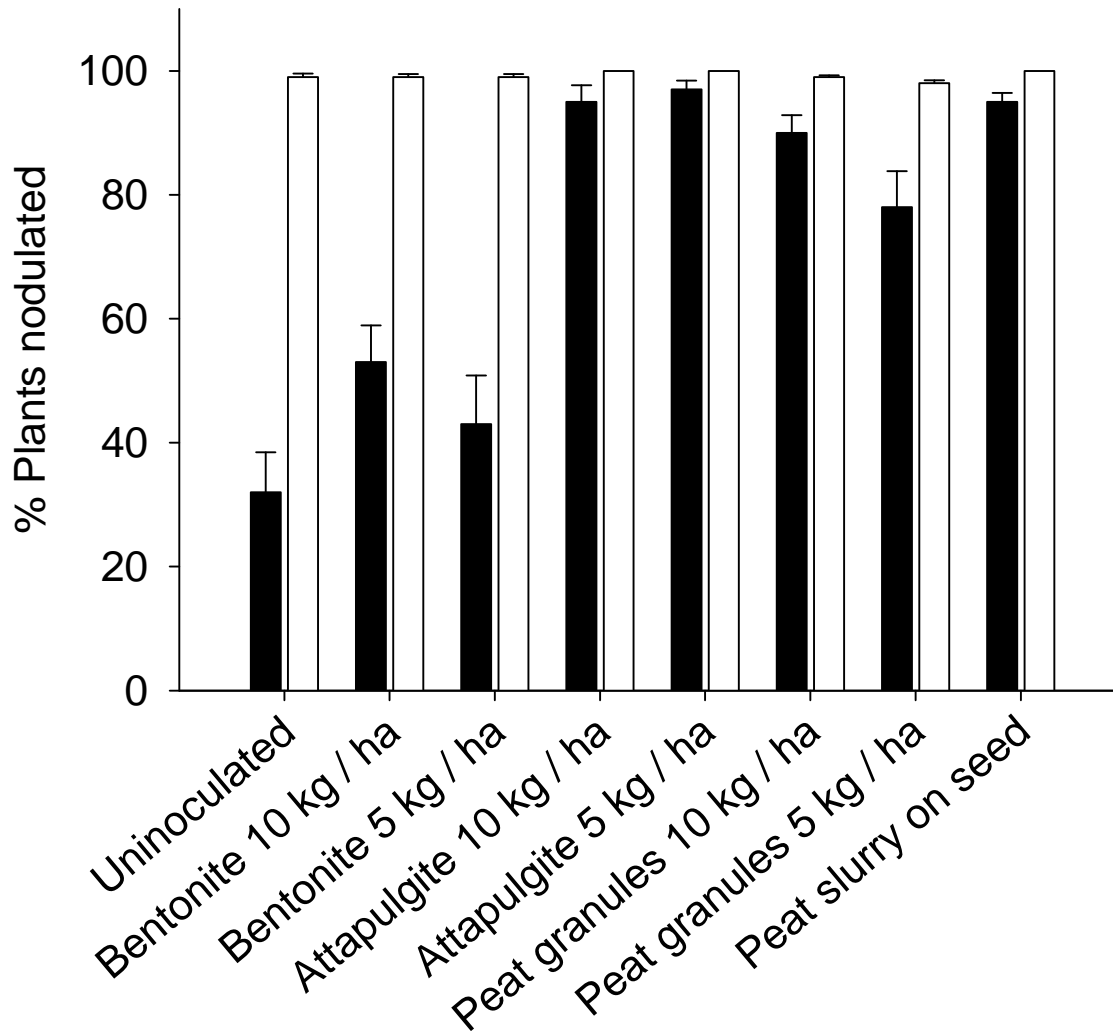
Attapulgate granules



Bentonite granules



% Plant nodulation



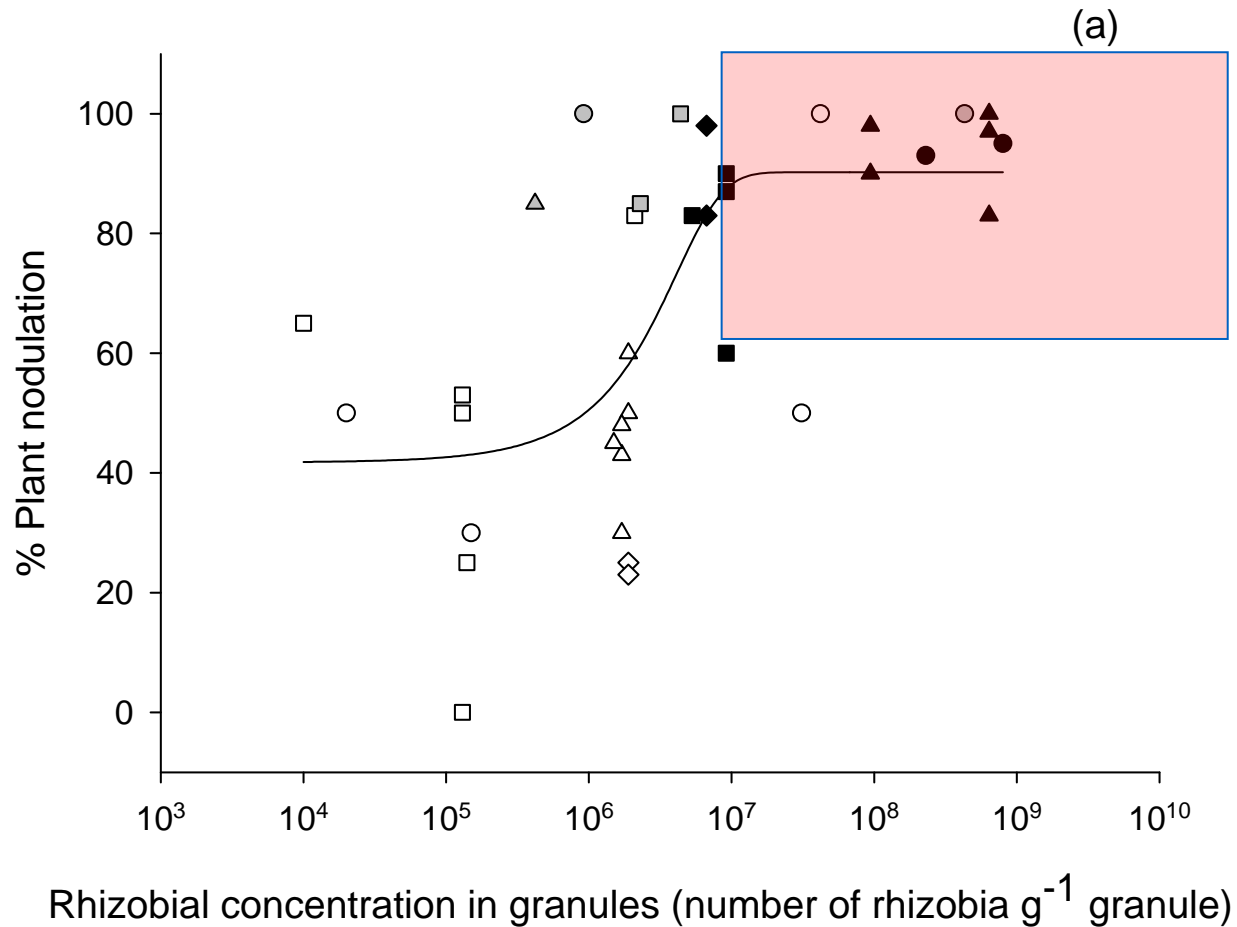
Data from 37 field trials separated by soil rhizobial population; black columns small soil populations; white columns large populations

Results

White symbols – bentonite

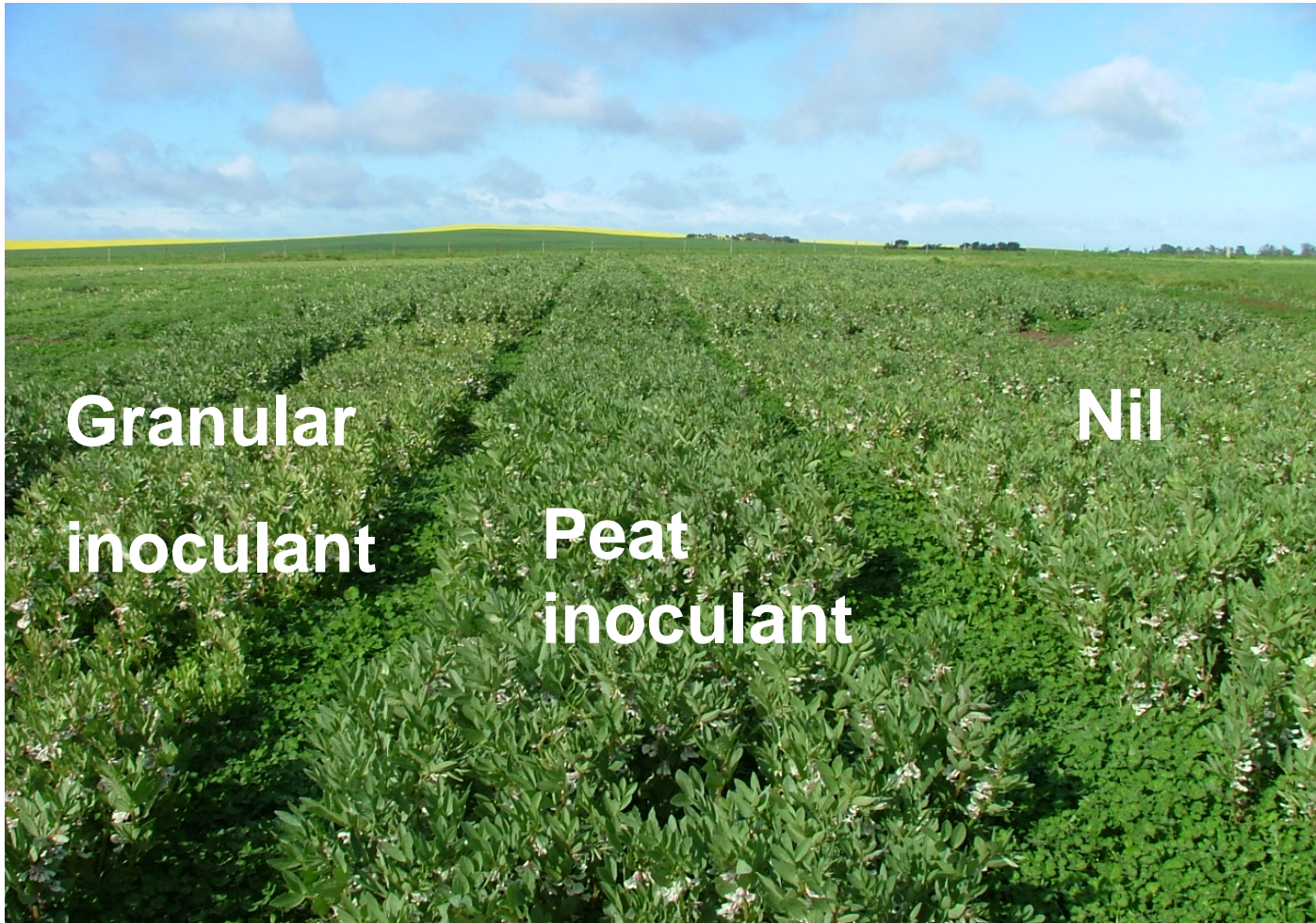
Grey symbols – attapulgite granules

Black symbols – peat granules



Inoculant potential

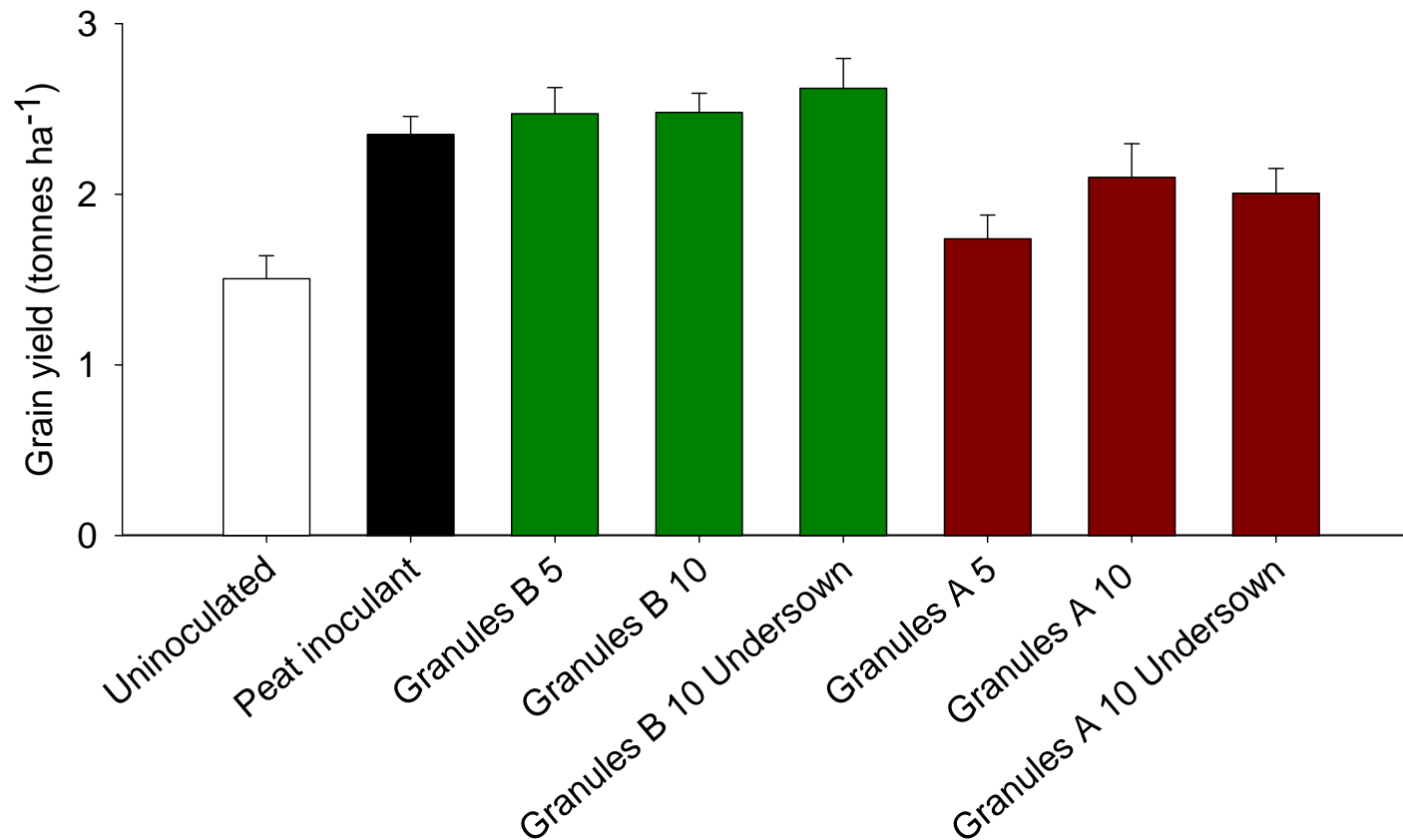
- Peat inoculant with 10^9 rhizobia applied at 250g / 100 kg seed and sown at 100 kg seed / ha = **2.5×10^{11} rhizobia / ha**
- Granular inoculant with 10^7 rhizobia applied at 10 kg / ha = **1×10^{11} rhizobia / ha**

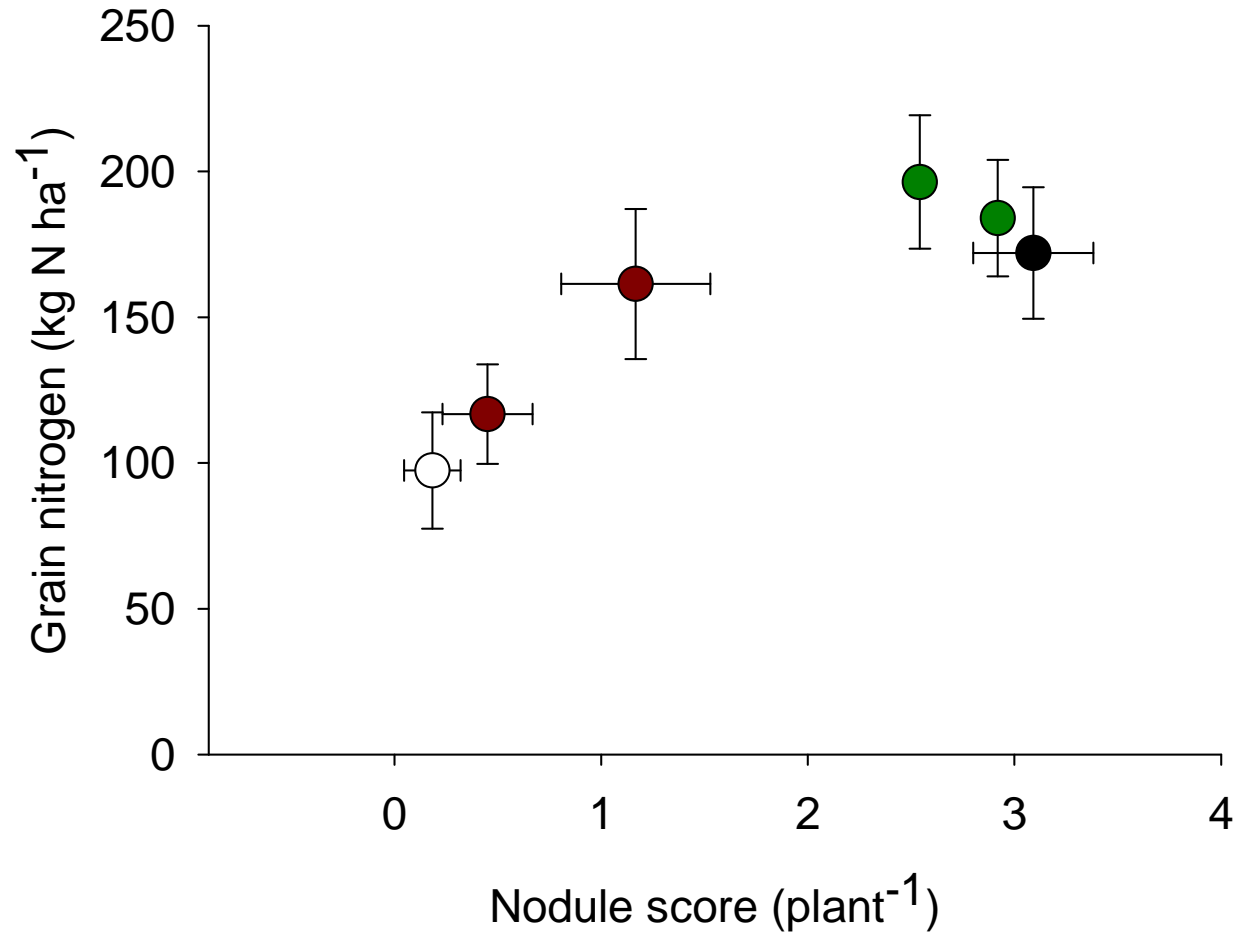


**Granular
inoculant**

**Peat
inoculant**

Nil





Conclusions

- Soil inoculants provide an option for inoculation when seeds contain fungicides / pesticides
- Granular inoculants provide an option for inoculation in dry soil environments
- Liquid inoculants are as effective as peat slurry inoculants
- Granular inoculants can be as effective as peat slurry inoculants, but require $>10^7$ cells g^{-1} inoculant

Acknowledgments

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