Maximising Nitrogen Fixation in Grain Legumes

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N benefits of legumes

- Mineral N is conserved in soil during the legume growth
- Addition of N-rich residues following the legume harvest
- Function of crop N fixation capacity and dry matter production
- Amount varies with site, season and crop management

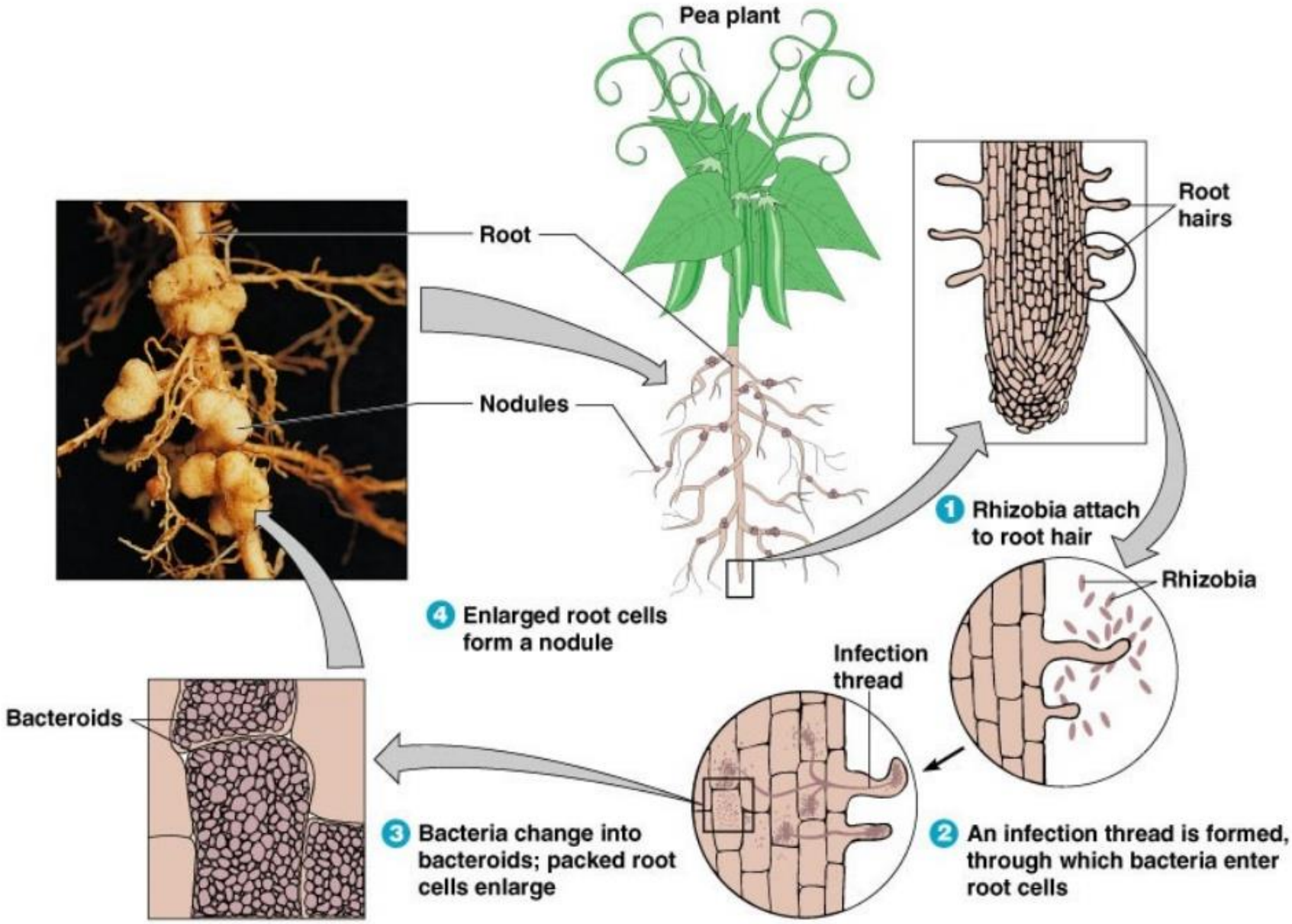
Maximising N fixation

- ✓ Getting inoculation right
- ✓ Optimising plant nutrition and agronomy
- ✓ Reducing available nitrogen in soil

What are Rhizobia?

- Rhizobia are bacteria that live in the soil, on plant roots and in legume nodules
- Form a symbiotic relationship with plants
- Only fix nitrogen when inside a legume nodule
- There are many species and strains of rhizobia
- They are host specific
- Require nutrition, water and aeration for growth
- Are killed by heat, dessication, pH extremes and toxic chemicals

Formation of a Root Nodule



What are Inoculants?

- prepared cultures of rhizobia protected in carriers
- to supply selected strains in large numbers to the roots soon after germination

Several different formulations:

- Moist peat
- Granules (peat, bentonite clay, attapulgite clay)
- Liquids
- Freeze dried

Inoculant Groups

TABLE 1 Examples of legume inoculant groups used in Australian agriculture and their rhizobia. Currently, 39 different legume inoculants are manufactured in Australia, covering about 100 legume species

Rhizobia	Commercial inoculant group	Legumes nodulated
Sinorhizobium spp.	AL	Lucerne, strand and disc medic
	AM	All other annual medics
Rhizobium leguminosarum bv. trifolii	B	Perennial clovers
	C	Most annual clovers
Bradyrhizobium spp.	G[1]	Lupin, serradella
	S[1]	Serradella, lupin
Mesorhizobium ciceri	N	Chickpea
Rhizobium leguminosarum bv. viciae	E[2]	Field pea and vetch
	F[2]	Faba bean and lentil
Bradyrhizobium japonicum	H	Soybean
Bradyrhizobium spp.	I	Cowpea, mungbean

1 Both inoculant groups G and S can be used for lupin and serradella
2 Although group E is recommended for pea/vetch and group F for faba bean/lentil, if required group E can also be used for faba bean/lentil and group F used for pea/vetch

Inoculant group	Host Plant - Common Name	Nodule N™ Peat		EasyRhiz™	EasyRhiz™ Protectant
	Pack size	Std	Jumbo	Vial	Foil
STRAIN	Seed treated per pack→	kg	kg	kg	(powder)
AL, "Lucerne" (RRI128)	Lucerne, Strand medic, Disc medic	25	125	100	100g
AM, "Medic" (WSM1115)	Barrel medic, Burr medic, Snail medic, Sphere medic, Gama medic, Murex medic	50	250	200	250g
B, "White clover" (TA1)	White clover, Red clover, Strawberry clover, Alsike clover, Berseem (Egyptian) clover, Cluster or Ball clover, Suckling	25	125	100	100g
C, "Sub clover" (WSM1325)	Crimson clover, Cupped clover, Helmet clover, Purple clover, Rose clover, Sub clover	50	250	200	250g
	Arrowleaf clover, Balansa clover, Gland clover, Persian	25	125	100	250g
E, "Pea" (SU 303)	Field pea, Grass Pea, Common vetch or Tare, Bitter vetch, Lathyrus, Purple vetch, Pea, Woolly pod vetch	-	500	500	250g
F, "Faba" (WSM1455)	Faba, Tick or Broad bean	-	500	500	250g
	Lentil	-	250	250	250g
G, "Lupin" (WU425)	All lupin	-	500	500	250g
H, "Soy" (CB1809)	Soybean	100	500	500	250g
I, "Mung Bean" (CB1015)	Cowpea, Mung bean, Moth bean, Dune bean, Rice bean, Snake bean, Creeping vigna	100	–	500	250g
J, "Lab Lab" (CB1024)	Dolichos lablab, Pigeon pea, Hyacinth bean,	100	–	500	250g
	Perennial horse gram, (Axillaris)	50	–	250	250g
M, "Siratro" (CB756)	Butterfly pea, Atro, Tropical kudzu, Puero,		–	200	250g
	Glycine, Siratro, Jack bean, Calopo, Gambia pea, Phasey bean, Velvet bean, Banana bean, Wing bean or Goa, Wynn		–	100	250g
N, "Chickpea" (CC1192)	All Chickpea		500	500	250g
P, "Peanut" (NC92)	Peanut or Groundnut		–	500	250g
S, Serradella (WSM 471)	All Serradella	50	250	200	250g
	Special Inoculants				
5G1B	Adzuki bean		–	200	250g
WSM1497	Biserrula		-	50	100g
SU343	Birdsfoot trefoil *(Lotus corniculatus)*		–	25	100g
CB1717	Burgundy bean		–	100	100g
CC283b	Caucasian (Kura) clover		–	50	100g
CB1923	Centro, Centurion		–	200	250g
CB3126	Desmanthus		–	100	250g
	Leucaena			250	250g
CB627	Desmodium		–	50	100g
SU277	Fenugreek		–	200	250g
CC511	French or Common bean, Navy, Kidney, Dry, Lima beans		–	250	250g
CB3035	Guar or Cluster bean		–	250	250g
CB2312	Jointvetch, *Aeschynomene*		–	100	100g
CB782	Kenya white clover *(Trifolium semipilosum)*		–	50	100g
CB376	Lotononis		–	25	100g
CC829 (Lotus)	Lotus, *Lotus pedunculatus*	-	–	25	100g
CIAT3101	Pinto peanut		–	250	250g
CC1099	Sainfoin		-	100	100g
CB1650	Stylo - Caribbean stylo *(Stylosanthes hamata)*		–	50	100g
CB3481	Stylo - Caatinga stylo *(Stylosanthes seabrana)*		-	50	100g
CB82	Stylo - All other Stylo (Fine stem, Shrubby, Townsville)		–	50	100g
WSM 1592	Sulla		–	100	100g
CC1502	Tree lucerne or Tagasaste		–	25	100g

Source: New Edge Microbials

How to handle inoculants

- Do keep them cool
- Don't freeze them
- Do transport them in esky, styrofoam boxes
- Don't leave them on the dash of the ute
- Do check the quality of batch – be aware of Green Tick Logo

- Don't use out of date stock
- Don't store with chemicals, fertilisers

Be aware of…

- Toxicity of micronutrients, particularly Zn, Cu, Mo or Mg
- Do not mix with fungicides such as Sumisclex or Rovral
- Do not mix with herbicides such as MCPA, 2,4-D and Dinseb
- Do not mix with insecticides containing endosulfan, dimethoate, omethoate or carbofuran
- Plant into moist, cool soil
- Ensure equipment is clean
- Compatibility and reduced survival times with seed applied fungicides

Rhizobia and fertilisers don’t mix

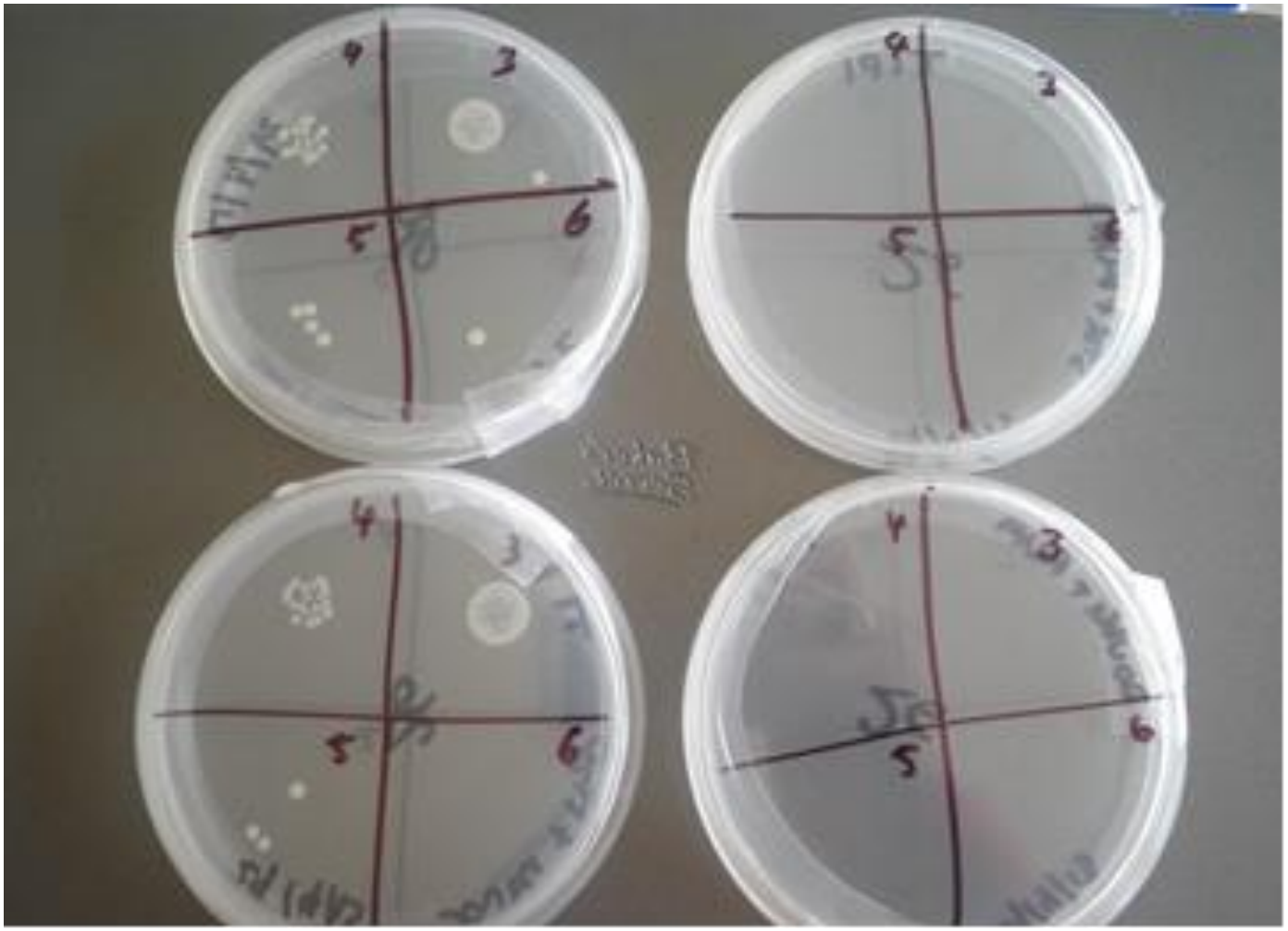
Case study at Inverell, NSW

‘Old’ soybean land

‘New’ soybean land

Laboratory assay -

Compatibility of soybean rhizobia inoculum (strain CB1809) with the liquid fertiliser



Seed treatments and Inoculants

TABLE 5.4 Compatibility of different rhizobia groups with seed-applied fungicides. Information sourced from commercial product information guides (Becker Underwood and Novozymes)

Inoculant group / crop	Fungicide type	Planting window of inoculated seed
E – pea, vetch	P-Pickle T	6 hours
	Gaucho® 600 FL	4 hours
F – faba bean, lentil	Gaucho® 600 FL	24 hours
	P-Pickle T	24 hours
	Thiram	Compatibility not known
G – lupin	Rovral	6 hours
	Thiram	24 hours
H – soybean	not compatible with seed dressings	
N – chickpea	P-Pickle T	6 hours
	Thiram	6 hours
	Apron® XL 350 6 hours	6 hours
	Gaucho® 600 FL	6 hours
P – peanut	not compatible with seed dressings	

Follow up in the paddock

- To ensure inoculation has been effective check plants in the paddock
- Assess nodulation 6 weeks after planting
- - remove plants and soil to a depth of 10-15cm
- - carefully wash soil from roots in bucket of water
- - compare against nodule scores
- Effective nodules will be pink when cut, they will be fixing nitrogen
- Nodules that are white or green, are not fixing N

Estimated average amounts of N fixed by crop legumes in Australia

Legume	%N fixed	Shoot dry matter (t/ha)	Total crop N (kg/ha)	Total N fixed[1] (kg/ha)
Lupin	75	5.0	176	130
Pea	66	4.8	162	105
Faba bean	65	4.3	172	110
Lentil	60	2.6	96	58
Soybean	48	10.8	373	180
Chickpea	41	5.0	170	70
Peanut	36	6.8	268	95
Mungbean	31	3.5	109	34
Navy bean	20	4.2	148	30

[1] Total N fixed = %N fixed x total crop N; Data sourced primarily from Unkovich et al 2010 And on p. 47 of 'Inoculating Legumes: a practical guide'

Maximising N fixation

- The amount of N fixed by a pulse crop is largely influenced by how well that crop grows. More crop biomass = more N fixed by that crop, provided it is well nodulated.
- The amount of N fixed by a legume does not equal the amount available for the next crop. N is removed in the harvested grain and that N remaining in the crop residue then needs to be mineralised by microbial activity before it is available to the next crop.
- High soil N levels can significantly reduce N fixation.
- Sowing at the optimum time for maximum crop biomass leads to greater amounts of N fixed.

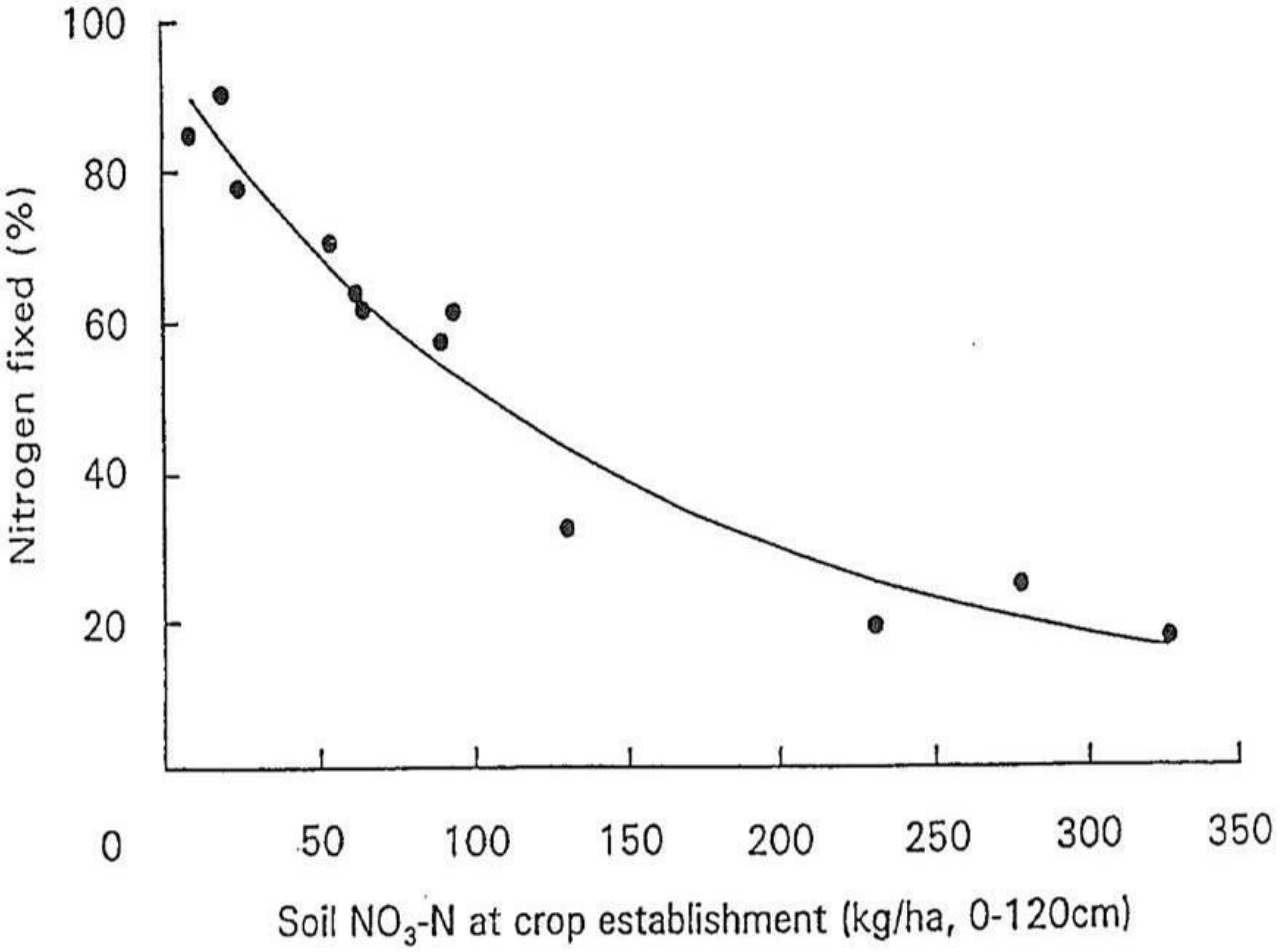
Soybean variety trial, Bundaberg

Variety!	Biomass (t/ha)	%Ndfa	N fixed (kg/ha)
A6785	9.4	86.3	307
Bunya	7	77.4	218
Eagle	9.3	81.1	262
Fernside	7.8	85	225
H173b-5	9.6	83	260
K173-19	8.9	80.6	257
M085-2	9	93.9	314
M087-2	8	80	239
M087-6	8.7	91.2	292
M103-17	9.9	98	322
M103-22	9.3	76.1	255
M103-3	8.8	92.6	322
N122B-10	8.3	89.8	282
N189-9	9	86.9	284
NF246-64	7.7	89.6	298
NK55C-32	9.9	90.3	312
P079A-17	9.4	80.4	237
P079A-19	9.3	86.7	268
S215B-53	9.2	91.1	314
Warrigal	9	91.4	299
Lsd (5%)	1.1	ns	ns

Richmond

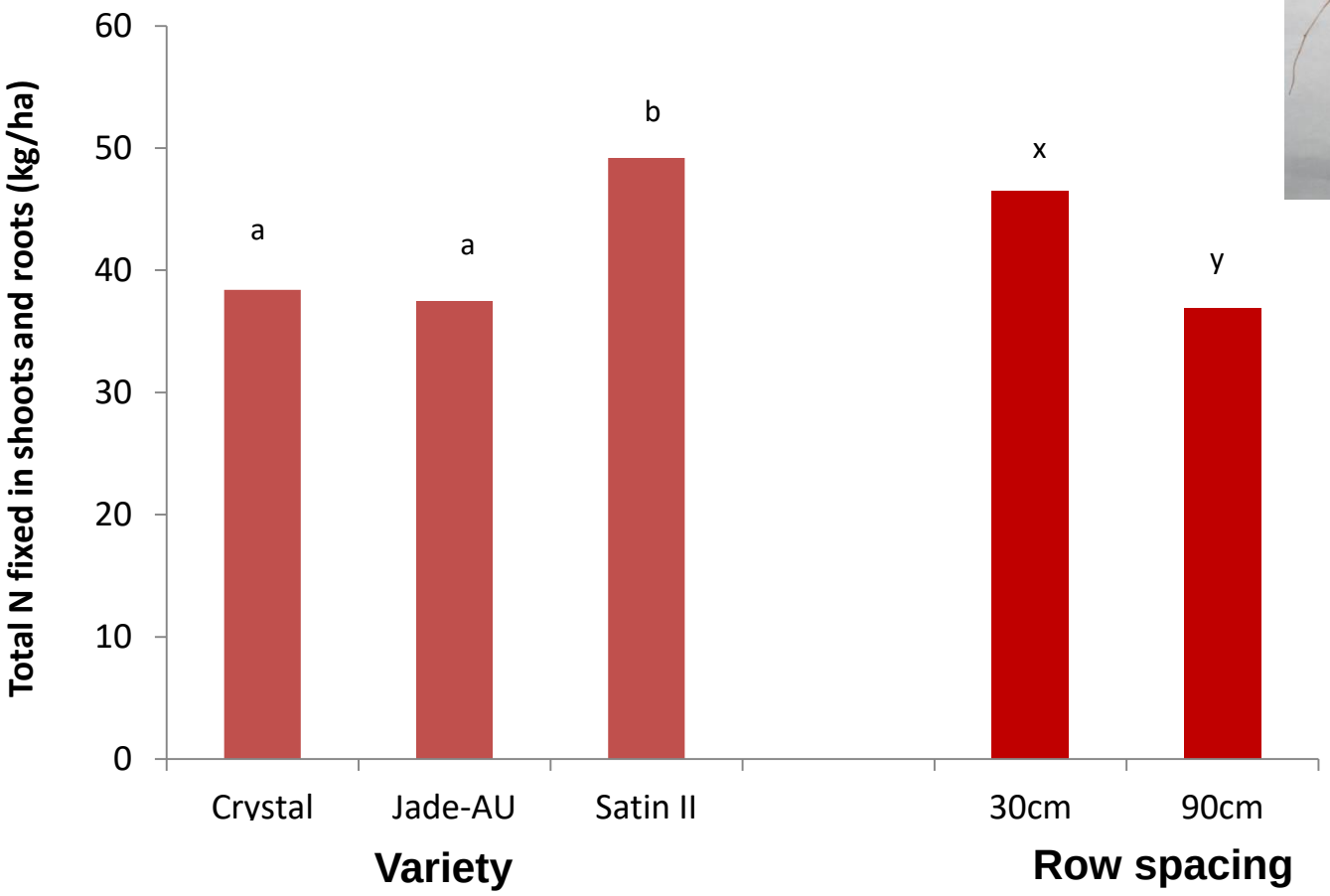
Hayman

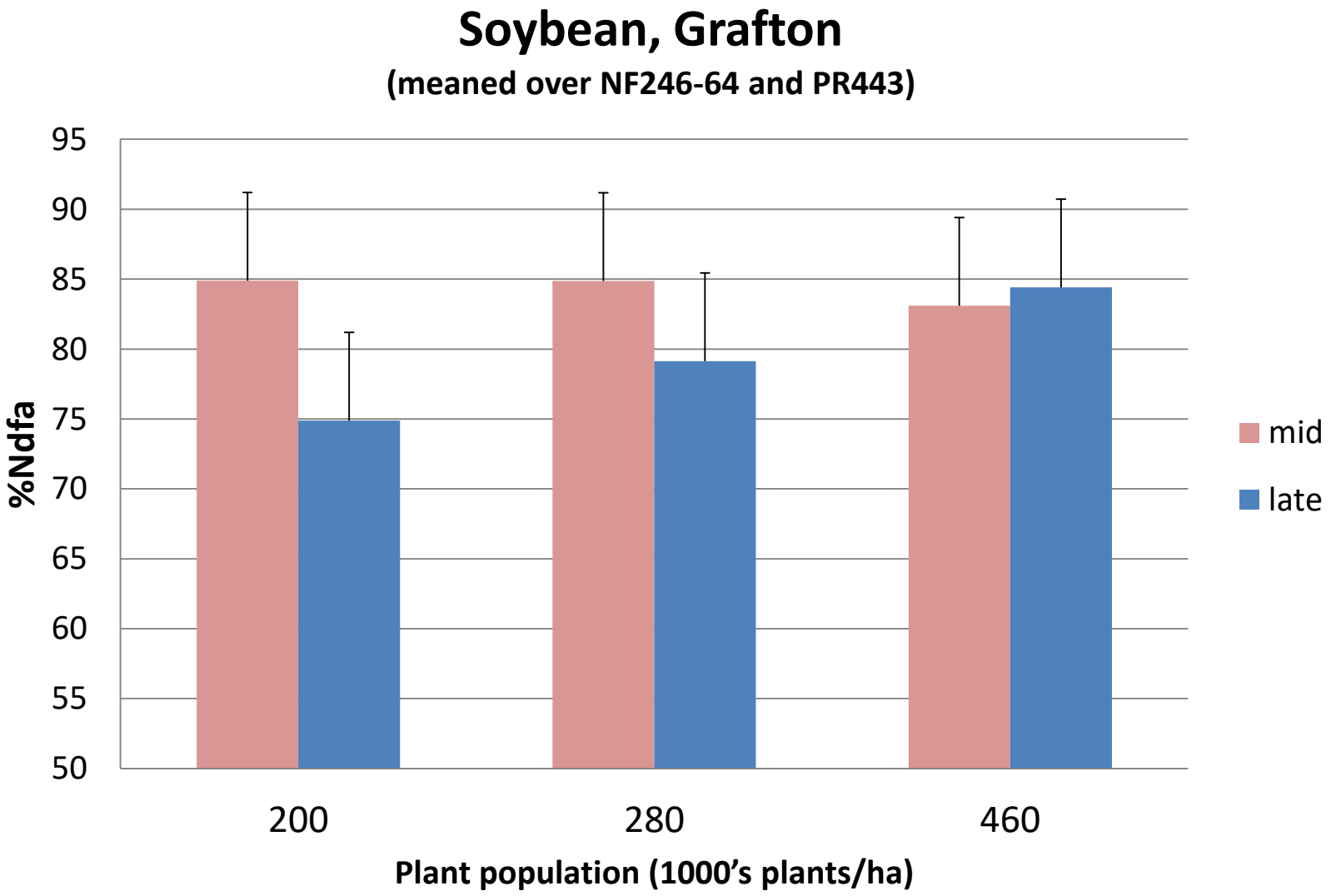
N fixation decreases as soil nitrate increases



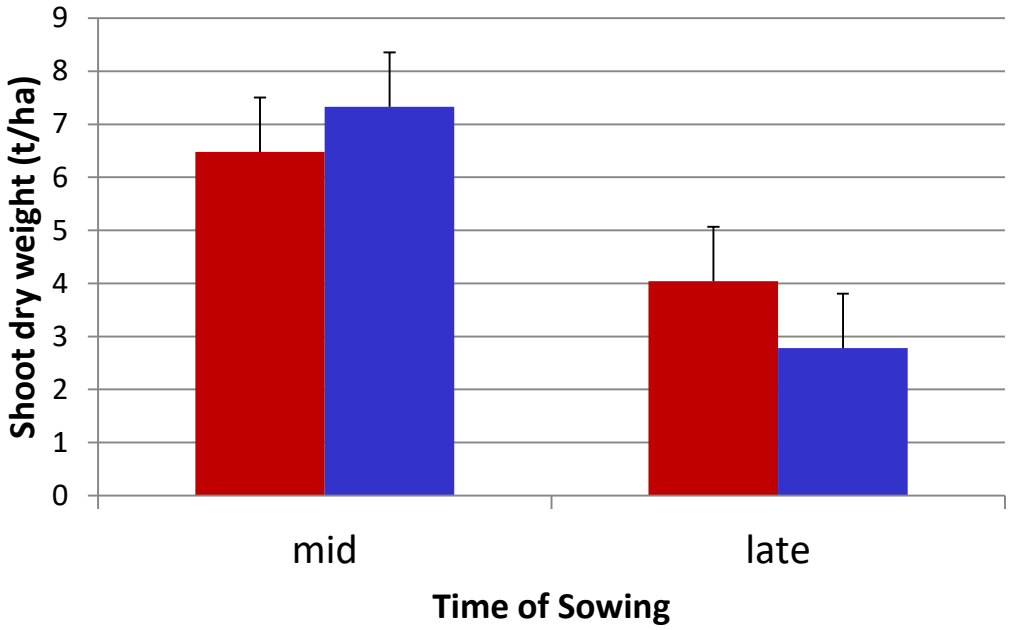
Doughton *et al.* 1993

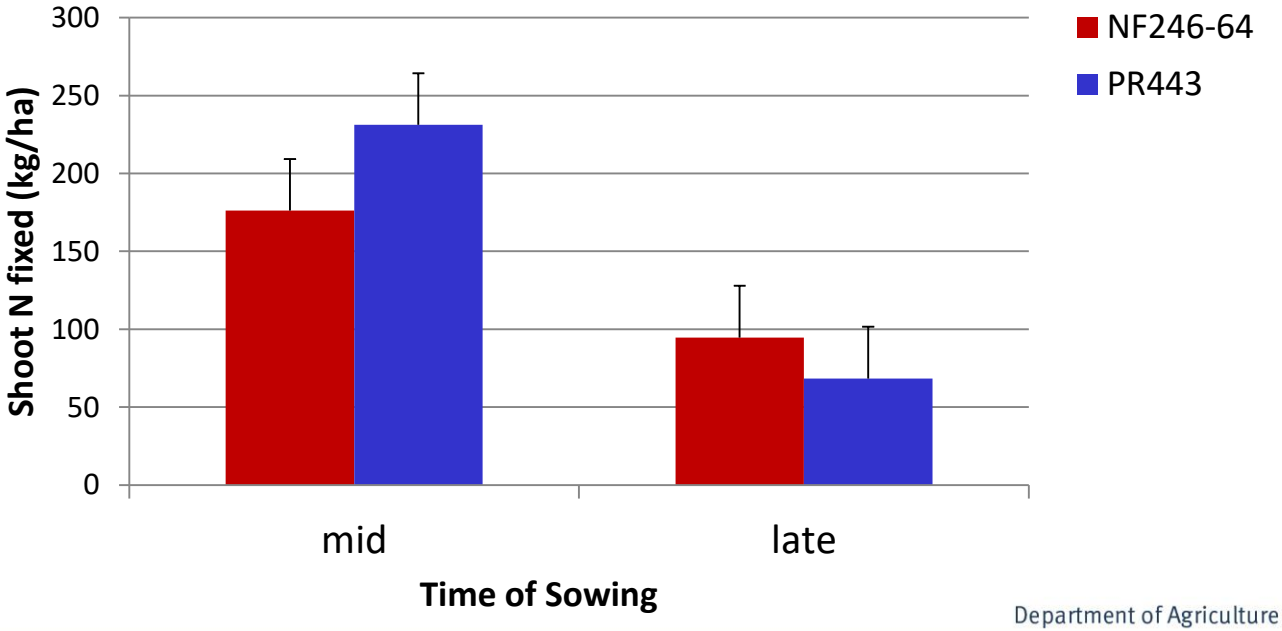
Mungbean N fixation





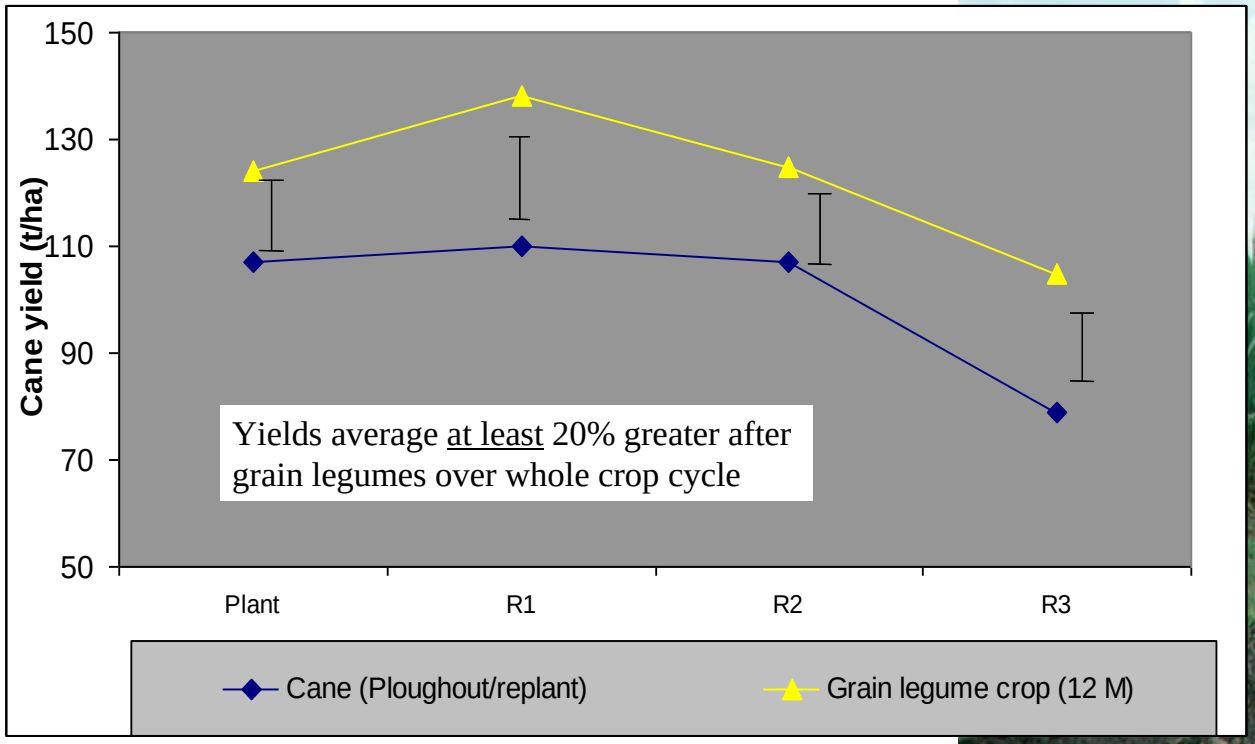
Soybean, Grafton

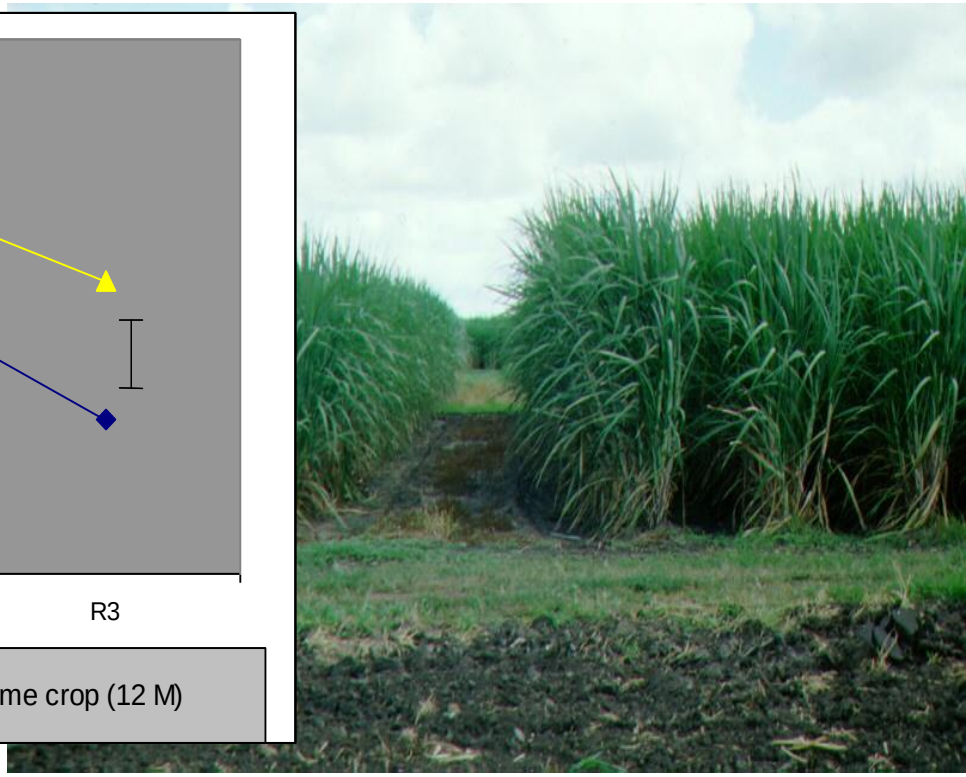




Legume breaks in sugarcane farming systems

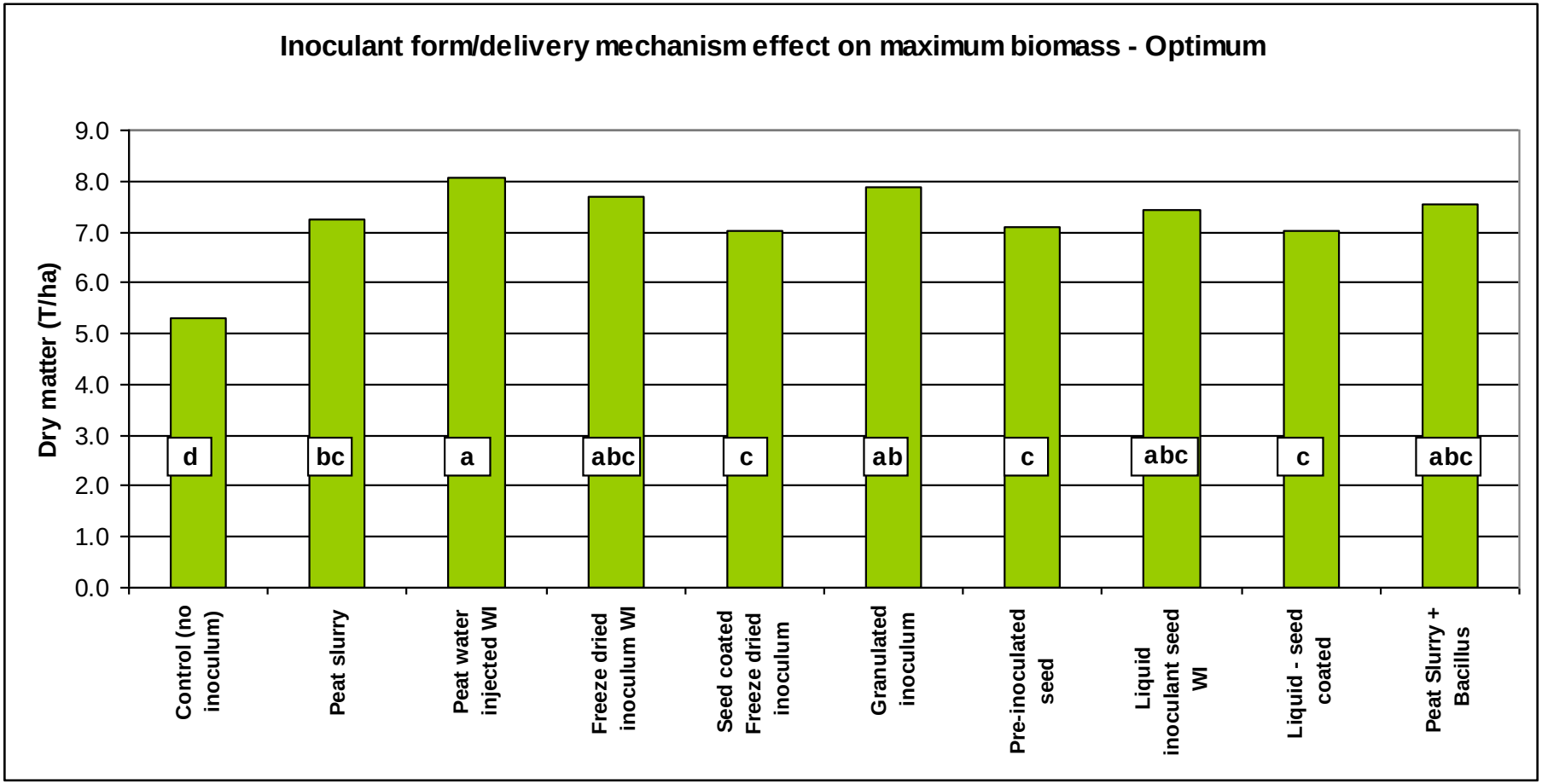
- 20% yield increase of cane after legume cf. continuous cane
- N benefit to plant cane crop
- Suppression of some key pathogens (soil C/N balance important)
- Advantages are greatest when legumes are combined with minimum/zero tillage and controlled traffic





Inoculation failures in coastal farming systems

Soybean Dry matter at mid-pod fill



Summary

- Get inoculation right
  - Rhizobia need to be kept alive
- Get the agronomy of crop right
  - Narrower row spacing at same population can increase N fixation
- Get the nutrition of the crop right
  - Healthier the crop the more N fixed
  - N fertiliser not necessary