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Section 7

Pastures

Identifying the causes of unreliable N fixation by medic based pastures: 2016 results

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RESEARCH

Searching for answers

Location:
Piednippie - Brent Cronin & Family
Rainfall
Av. Annual: 379 mm
Av. GSR: 304 mm
2016 Total: 485 mm
2016 GSR: 323 mm
Paddock History
2016: Mace wheat
2015: Mace wheat
2014: Pasture - oats
2013: Mace wheat
Soil Type
Calcareous grey sand
Plot Size
6 m x 1.5 m x 3 reps

Location:
Pinbong - Greg Scholz & Family
Rainfall
Av. Annual: 321 mm
Av. GSR: 227 mm
2016 Total: 378 mm
2016 GSR: 261 mm
Paddock History
2016: Medic
2015: Barley
2014: Mace wheat
2013: Mace wheat
Soil Type
Red sandy loam
Plot Size
6 m x 1.5 m x 3 reps

Key messages

- **Growers should be aware that the application of certain broad-leaved herbicides can result in a reduction in shoot dry matter of medic pastures.**
- **Application of a full label rate of Agritone 750 (late) resulted in the largest reduction of shoot dry matter.**
- **Applying P to a soil with low P reserves when establishing a medic pasture boosts shoot and root dry matter, improves root health and improves N fixation.**
- **Growers should also be aware that the use of herbicides can reduce nodulation and N_2-fixation in medic pastures.**

Why do the trial?

Many medic pasture phases are now being managed to produce vigorous medic dominant pastures using a range of herbicides and pesticides to control weeds and pests. However, it appears that some of these pastures are not producing high nitrogen (N) reserves for the following cereal crops. The broad aim of this SAGIT funded project is to assess the impact of soil nutrition, current herbicides, adjuvants and rhizobial inoculants on N fixation by medics under field conditions typical of the upper Eyre Peninsula. This article reports on the second year of field trials in this three year SAGIT funded project. First year results are available in the Eyre Peninsula Farming Systems Summary 2015 p 209-213.

How was it done?

Two replicated field trials were established on Eyre Peninsula in 2016; one representative of typical mallee environments in SE Australia (Greg Scholz - Pinbong) and the other on a grey highly calcareous sandy soil (Brent Cronin - Piednippie). Background rhizobia populations, soil moisture and soil fertility were determined prior to seeding. Treatments (Table 1), to simulate herbicide residues were imposed on 27 January and the trials were later sown on 11 May (Piednippie) and 12 May (Pinbong) with all nutrition treatments applied at sowing. Both trials were sown as a split plot design with the main plots comprising the strand medic varieties Angel and Herald, and management options as subplots (nutrition, herbicides and inoculants) applied to both varieties.

Table 1 Treatment details

Treatment	Active ingredient	Chemical group	Application rate (units/ha)
Post-emergence			
Agritone 750	750 g/L MCPA (as dimethylamine salt)	I	330 ml
Agritone 750 (2)	750 g/L MCPA (as dimethylamine salt)	I	330 ml
Agritone 750 - Late	750 g/L MCPA (as dimethylamine salt)	I	330 ml
Broadstrike	800 g/kg Flumetsulam	B	25 g + Uptake oil
Tigrex	250 g/L MCPA as the ethyl hexyl ester; 25 g/L Diflufenican	F I	100 ml + 200 ml *wetter
Tigrex + Verdict	250 g/L MCPA as the ethyl hexyl ester; 25 g/L Diflufenican 520 g/L Haloxyfop	F I A	75 ml + 200 ml *wetter 100 ml
LVE Agritone	570 g/L MCPA as the 2-ethylhexyl ester	I	250 ml + 200 ml *wetter
LVE Agritone + Verdict	570 g/L MCPA as the 2-ethylhexyl ester 520 g/L Haloxyfop	I A	250 ml + 200 ml *wetter 100 ml
Rustler	500 g/L Propyzamide	K	1 L
Verdict	520 g/L Haloxyfop	A	75 ml + uptake oil
Herbicide residues			
Intervix	33 g/L Imazamox; 15 g/L Imazapyr	B	50 ml
Logran	750 g/kg Triasulfuron	B	1.25 g
2,4-D Amine	625 g/L 2,4-D (as dimethylamine salt)	I	1 L
Nutrition	**Delivered as**		
Nitrogen	Urea		100 kg
Phosphorous	Phosphoric acid		10 kg
Phosphorous	Phosphoric acid		5 kg
Zinc	Zinc sulphate		2 kg
Control 1	Inoculated		
Control 2	Not Inoculated		

**Wetter = BS1000*

Post emergent herbicide treatments were applied after the third trifoliate leaf stage on 5 July 2016 at a water rate of 100 L/ha, with the exception of the Agritone 750 (2) and Agritone 750 - late treatments that were later imposed when medic plants were 5-7 cm in diameter on 19 July and 16 August 2016 respectively. Two rates of phosphorus (P) were applied to determine the lower limit of P response. The Pinbong site had mostly broad-leaved weeds (turnip), while the Piednippie site had grassy weed problems (ryegrass). Plots were kept free of weeds as much as possible to avoid competition effects from the herbicide treatments, with plots hand weeded if necessary.

Plots were sampled on 17 August to determine the number of viable nodules, early dry matter and root health and weight. Sampling was also done on 6 September to estimate medic productivity (late DM) and N_2-fixation by the *^{15}N natural abundance technique*. Contribution to N reserves in the soil will also be measured by sampling for mineral N in the root zone in autumn 2017.

What happened?

Pasture emergence and establishment was more rapid when compared to the 2015 trials because the medic was sown into wet and warm soil. Plant density after emergence was not affected by the herbicide residue treatments but was reduced ($P<0.05$) by urea applied below the seed at sowing. At Pinbong, mean site plant density was 97 plants/m^2 but urea reduced this to 74 plants/m^2; and at Piednippie mean site plant density was 110 plants/m^2 and with urea only 93 plants/m^2. A positive growth response to both rates of P (5 and 10 kg P/ha) was evident during the early stages of the season at Piednippie, and stunted growth was observed in the Tigrex and Agritone 750–late treatments at both trial sites.

Table 2 Effect of variety on nodulation, dry matter and root health

Site	Variety	Total nodules/ plant	Effective nodules/ plant	Ineffective nodules/ plant	Root damage score (0 Good - 15 Bad)	Root DM (mg plant)	Shoot DM (mg/plant)	Biomass (t/ha)
Pinbong	Angel	9.4	2.8	6.7	4.1	24.6	281.8	0.7
	Herald	9.1	3.1	6.0	4.0	26.0	311.7	0.7
	LSD (P=0.05)	*ns*	*ns*	*0.6*	*ns*	*ns*	*ns*	*ns*
Piednippie	Angel	7.9	5.8	2.1	3.3	13.3	146.4	1.0
	Herald	6.8	5.1	1.7	3.1	13.5	154.7	1.0
	LSD (P=0.05)	*0.5*	*0.5*	*0.3*	*ns*	*ns*	*ns*	*ns*

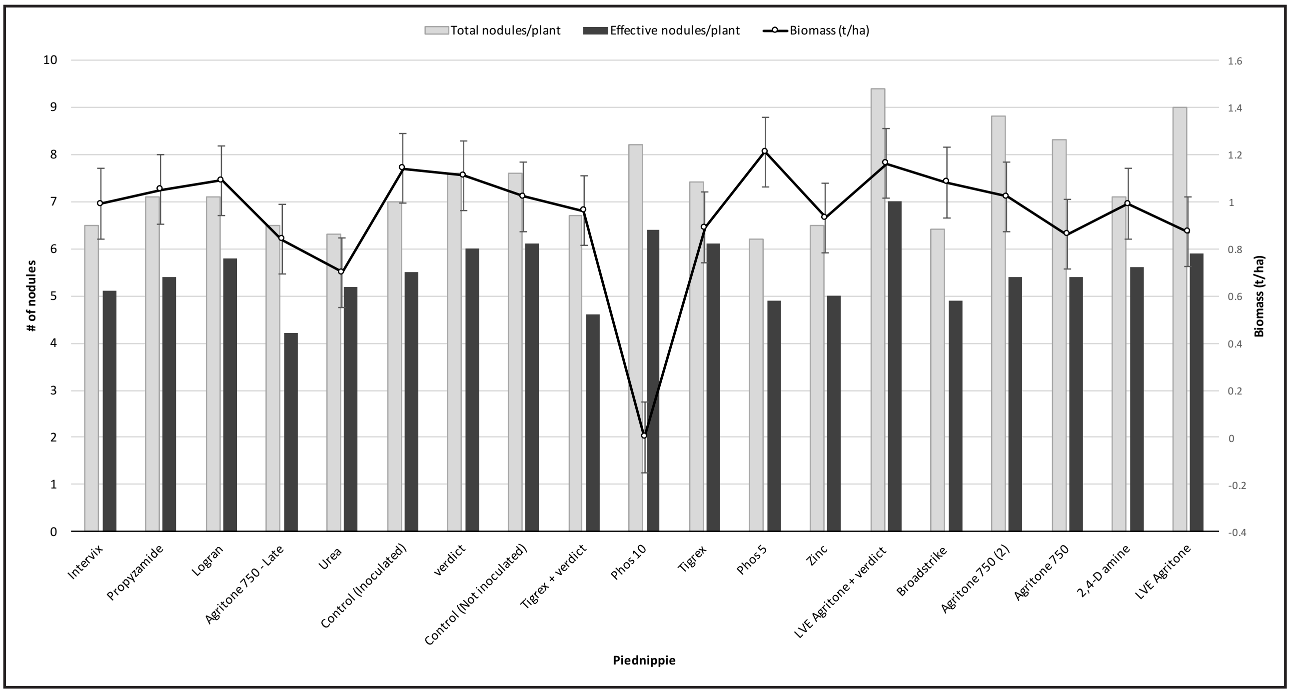

Figure 1 Total and effective nodule numbers per plant and biomass (t/ha) at Piednippie 2016

Differences in the performance of Herald strand medic and its successor Angel, which has tolerance to sulfonylurea herbicide residues, were measured (Table 2). There were no differences in variety responses to treatments imposed at both sites for biomass, shoot DM, root DM and root health. At Piednippie, Angel nodulated better than Herald with more total nodules per plant, and total effective nodules per plant.

Average shoot biomass in late August at Piednippie was 1.03 t/ha but some treatments had large effects on dry matter production. Phos 10 was the only treatment that increased biomass compared to the inoculated control, with no response at 5 units of P (Phos 5). Biomass production (t/ha) was reduced by Tigrex (0.89), urea (0.7), LVE Agritone (0.87), Agritone 750 (0.86) and Agritone 750 – Late (0.84) (Figure 1).

Total number of nodules per plant, which averaged 7.4 at Piednippie, increased from the inoculated control with Phos 10, LVE Agritone+Verdict, LVE Agritone, Agritone 750-2 and Agritone 750. However, apart from the Phos 10 treatment, these increases were associated with an increase in the number of ineffective nodules per plant, possibly indicating the plant response to the herbicide stress was to produce more nodules to compensate for those that were not working.

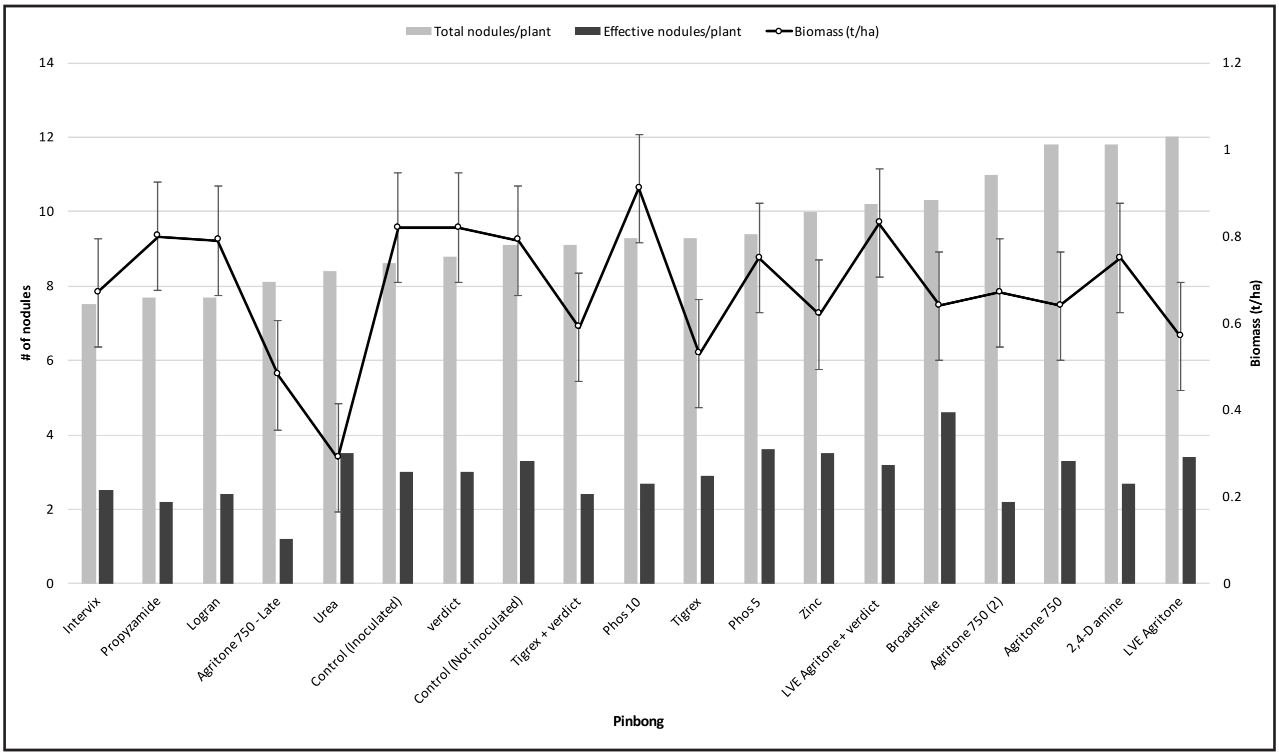

Figure 2 Total and effective nodule numbers per plant and biomass (t/ha) at Pinbong 2016

At Pinbong, shoot biomass was very poor and averaged only 0.7 t/ha in late August. There was no growth response to the nutrition treatments (P and zinc), and no other treatment performed better than both the inoculated and uninoculated controls. However, urea, Tigrex, Tigrex+verdict, LVE Agritone and Agritone 750-Late all resulted in large reductions in biomass (Figure 2). There was an increase in the total number of nodules (site mean 9.3/plant) for Agritone 750, Agritone 750-2 and LVE Agritone, however, no treatment had lower total nodules than the inoculated control. Total number of effective nodules per plant was not affected by any of the treatments imposed, however total number of ineffective nodules per plant (site mean 6.3) was increased by LVE Agritone, Agritone 750 and Agritone 750-2. Root damage score, which is a measure of root health (0 = good – 15 = bad), was decreased by only Agritone 750-Late.

Plant and soil nitrogen (2015 results)

At Pinbong, measures of plant N from the ^{15}N *natural abundance* analysis showed that both medic varieties and all treatments resulted in similar total N (kg/ha) and fixed N (kg/ha and kg/t DM). The percentage of N fixed at this site was more than 90% and N fixed per tonne of dry matter was about 24 kg N/t DM (Table 3). These amounts were higher than at Piednippie (65% Nfix and 19 kg N/t DM) (Table 3). At Pinbong, the amount of N fixed (kg/ha) ranged from 15 (Agritone 750 treatment) to 26 kg/ha (plus P treatment).

At Piednippie there were treatment effects on fixed N (kg/ha); fixed N (kg/tDM) and total N (kg/ha). Phosphorous addition was the only treatment that increased the amount of fixed N (23 kgN/ha) compared to the control (9 kgN/ha), whereas late Agritone (5 kgN/ha) was the only treatment to fix less N than the control.

Soil mineral N levels in the autumn after the trials were conducted was not affected by treatments at both sites. Total mineral N (0-60 cm) was higher, on average, at Pinbong (101 kg N/ha) than at Piednippie (78 kg N/ha).

Table 3 Fixed N (kg/ha) and N fixed per tonne of dry matter (kg/tDM) at Piednippie and Pinbong in 2015

Site		Fixed N (kg/ha)	Fixed N (kg N/t DM)	Total N (kg/ha)
Pinbong	Average	20.5	23.8	22.1
	Range	15-26	22-25	16-28
Piednippie	Average	10.9	18.8	16.1
	Range	5-23	17–25	9-33

What does this mean?

The amounts of N fixed per hectare by legumes are usually related to plant growth with around 20 kg of N reported to be fixed for every tonne of above-ground dry matter produced. Our results show substantial variation about this level associated with impacts of nutrition and herbicide use. However, 30-60% of the legume's total plant N may be below-ground associated with roots and nodules (Peoples and Baldock, 2001). Herbage production for the 2016 trials was only increased (28%) by applying 10 units of P at Piednippie, and this can be attributed to the low starting P reserves (Colwell P, 0-10 cm of 14 mg/kg) prior to sowing.

Our trials show that there can be a shoot DM penalty when certain herbicides are used to control broad-leaved weeds during the pasture phase. There was a reduction in shoot DM by applying Agritone 750 (25%), Agritone LVE (23%) and Tigrex (22%) at Piednippie, and by applying Tigrex (35%), Agritone LVE (30%) and Tigrex + Verdict (28%) at Pinbong. The biggest reduction in shoot DM at both trial sites was from the application of Agritone 750 late (when plants were greater than 7 cm in diameter), with a reduction of 26% at Piednippie and 41% at Pinbong. Therefore, the timing of application is crucial in order to achieve maximum potential DM production by medic pastures. These reductions in shoot DM were associated with increased numbers of ineffective nodules and so we expect less total shoot N to be fixed and available for the next cereal crop. However, it should not be assumed that all of the shoot N fixed by legume pastures will immediately be available to crops, because the breakdown of shoot and root residues is dependent upon the rate of mineralisation, which is also dependant on various factors but mainly summer and autumn rainfall.

The 2016 findings are consistent with the trends measured in previous trials (2015), that pasture DM production is improved with the application of P when establishing new medic pastures, even on paddocks with moderate P reserves. The effects of herbicide application were also consistent, with the application of MCPA amine based (Agritone) herbicides increasing the proportion of ineffective nodules and reducing herbage production, especially when applied late in the season. Herbicides are essential in intensive farming systems, particularly in reduced tillage systems, however some chemicals may have a negative effect on pasture DM and more specifically on nodulation and N-fixation when applied during the medic pasture phase. These effects must be balanced against the value of weed control they provide.

It should also be noted that some of the chemicals used in this trial (Tigrex and LVE Agritone) are considered off label chemicals for use in medic pastures but have been included to make growers aware of the impact that they may have on medic nodulation, N-fixation and herbage production.

The ^{15}N *natural abundance* analysis from the 2016 season was not available at time of publication.

References

Peoples M, Baldock J (2001). Nitrogen dynamics of pastures: nitrogen fixation inputs, the impact of legumes on soil nitrogen to Australian farming systems. Australian Journal of Experimental Agriculture 41, 327-346.

Acknowledgements

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