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Identifying the causes of unreliable nitrogen fixation by medic based pastures

EXTENSION

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Location
Piednippie - Brent Cronin & Family
Rainfall
Av. Annual: 379 mm
Av. GSR: 304 mm
2017 Total: 247 mm
2017 GSR: 199 mm
2016 Total: 485 mm
2016 GSR: 323 mm
2015 Total: 215 mm
2015 GSR: 179 mm
Paddock History
2016: Mace wheat
2015: Mace wheat
2014: Pasture - oats
Soil Type
Calcareous grey sand
Plot Size
8 m x 1.5 m x 3 reps (medic)
6 m x 1.5 m x 3 reps (wheat)

Location
Pinbong - Greg Scholz & Family
Rainfall
Av. Annual: 321 mm
Av. GSR: 227 mm
2017 Total: 307 mm
2017 GSR: 150 mm
2016 Total: 268 mm
2016 GSR: 260 mm
Paddock History
2016: Medic
2015: Barley
2014: Mace wheat
Soil Type
Red sandy loam
Plot Size
6 m x 1.5 m x 3 reps

Key messages

- **Applying phosphorus (P) to a soil with low P reserves when establishing a medic pasture boosts shoot and root dry matter, improves root health and improves nitrogen (N) fixation.**
- **The addition of urea at seeding can reduce nodulation in medic pastures, and hence decrease N fixation.**
- **Residues of the herbicide Logran can severely stunt medic growth.**
- **Applying a full label rate of Agritone 750 late in the growing season decreases pasture production and N fixation in actively growing medic pastures.**
- **Any management practice that reduces medic biomass will reduce N fixation, such as the late application of certain herbicides.**
- **If it is necessary to use herbicides on your medic pastures, it is best to apply them early in the growing season.**
- **In a dry growing season when medic plants are already moisture stressed, herbicides will have little impact on medic production and N fixation.**

Why do the trial?

The broad aim of this three year SAGIT funded project was to investigate if current management tools for medic based pastures, such as herbicides, fertilisers and rhizobial inoculants, are affecting nitrogen (N) fixation by medic pastures under field conditions typical of the upper Eyre Peninsula (EP). These results should also be relevant to other low rainfall Mallee systems where medics are used.

Annual medics (*Medicago spp.*) are self-regenerating legumes that are well-suited to crop rotations on neutral to alkaline soils in the low to medium rainfall areas of southern Australia. They provide highly nutritious feed for livestock, act as a disease break for many cereal root pathogens, and improve soil fertility through N fixation. However, it appears that some of these pastures are not providing sufficient N reserves (as mentioned at local farmer meetings) for the following cereal crops, even where the medic has been quite productive. The longer term decline in protein levels in cereal crops are also of concern.

Location
Minnipa Agricultural Centre - Airport
Rainfall
Av. Annual: 325 mm
Av. GSR: 241 mm
2017 Total: 282 mm
2017 GSR: 155 mm
Paddock History
2016: Mace wheat
2015: Pasture
2014: Kord CLPlus wheat
Soil Type
Red sandy loam
Plot Size
8 m x 1.5 m x 3 reps

Medic pastures are now often sprayed with a range of herbicides and pesticides, both to ensure their productivity as pasture for livestock, and so minimal weed seeds are carried into the following cereal crop. This project examined if commonly used management strategies reduced N fixation by the medic pasture, and consequently mineral N supply to the following crop.

This article summarises three years of these trials. For a detailed summary of the results for the individual years, please refer to the Eyre Peninsula Farming Systems Summary 2015 p 209-213, 2016 p 142-146 and 2017 p 205-208.

How was it done?

There were a total of six field trials conducted over the life of the project, with two replicated field trial experiments established and conducted on the upper EP in 2015, 2016 and 2017. One was on a grey calcareous sandy soil on western EP at Brent Cronin's property at Piednippie, and the other on a red mallee loam of central EP (more typical of mallee environments in SE Australia) at Greg Scholz's property at Pinbong, and in 2017 at the Minnipa Agricultural Centre (MAC) Airport paddock. Medic was sown at 10 kg/ha as soon as a seeding opportunity arose at the start of all trials.

In each season there were post emergent herbicide treatments, chemical residue treatments and nutrition treatments, reported in previous EPFS Summary articles. In the first two years, two medic varieties: Herald and Angel were included, but in 2017 only Herald was grown. A high rate of urea was included as a treatment to simulate how medic would perform if sown into a soil with high N reserves. Herbicide product names are deliberately mentioned in this report as they were the treatments imposed, but we can assume that any other product with the same active ingredient would behave similarly.

Medic establishment and productivity was assessed during the season and fixed N production was monitored in three ways:

1. Scores of viable nodules on roots mid-season.
2. Soil mineral N in the root zone the following autumn.
3. N fixation by ^{15}N natural abundance technique.

Trials were sown as a split plot design in 2015 and 2016, and a completely randomised block design in 2017, with three replications. Trials were re-sown with wheat in the year after medic to assess impact of treatments on subsequent cereal production. Data was analysed using Analysis of Variance in GENSTAT version 18. The least significant differences were based on F probability = 0.05.

What happened?

Plant establishment and production

2015

There were only subtle differences in the performance of Herald and its group B herbicide resistant hybrid, Angel, hence results were presented as averages for both varieties. At Piednippie (grey calcareous sand) the mean site plant density was 135 plants/m^2. At Pinbong (mallee soil) the mean plant density was 136 plants/m^2. Plant density was not affected at either site by the treatments imposed. A growth response to P and zinc (Zn) was visible during the early stages of the trial, with the effect more visible at Piednippie. P increased shoot biomass (dry matter (DM)) at both sites.

At Piednippie, DM of the control was 0.52 t/ha. Biomass was increased by P to 1.30 t/ha. The Agritone 750 Late herbicide treatment decreased DM to 0.31 t/ha. At Pinbong the DM of the control was 0.96 t/ha. Biomass was increased by P to 1.20 t/ha. Agritone 750 decreased DM to 0.61 t/ha.

No other treatments affected medic growth.

2016

At Piednippie the mean site plant density was 110 plants/m^2. At Pinbong the mean site plant density was 97 plants/m^2. Plant density was not affected at either site by herbicide residues, nor nutrition. At Piednippie a positive early growth response to both rates of P (5 and 10 kg P/ha) was observed. Stunted growth was visible in the Tigrex and Agritone 750 Late herbicide treatments at both trial sites.

At Piednippie, DM in the control was 1.08 t/ha. Biomass was increased by 10 kg of P to 1.59 t/ha. Biomass was decreased by urea to 0.70 t/ha.

At Pinbong, DM in the control was 0.81 t/ha. No treatments increased biomass compared to the control. Agritone 750 Late (0.48 t/ha), Tigrex (0.53 t/ha) and urea @ 100 kg/ha (0.29 t/ha) all decreased the amount of shoot biomass compared to the control.

2017

In very dry seasonal conditions at Minnipa (heavier mallee soil) the mean site plant density was 223 plants/m^2. At Piednippie the mean site plant density was 218 plants/m^2. Plant density was not affected by herbicide residues, nor nutrition.

However, once plants reached the 1-2 trifoliate leaf stage, it became apparent that Logran, applied after seeding to simulate herbicide residues in the soil, was stunting growth, with the effect more pronounced at Minnipa, where most plants failed to develop beyond the first leaf stage.

For other treatments, once plants had progressed to the 2-3 trifoliate leaf stage, P and Zn were observed to have a positive early growth effect, with the effect more visible at Piednippie; but this was not consistent across all treatment replicates. The other residual herbicide treatments of Intervix and Lontrel did not appear to have had any early effect on medic growth.

At Minnipa, DM prior to flowering in the control was 446 kg/ha. Biomass was decreased by the residual Logran treatment to only 34 kg/ha, with the stunted plants never recovering. All other treatments produced biomass similar to the control at this site.

At Piednippie, DM prior to flowering in the control was 134 kg/ha. No treatments reduced biomass compared to the control. In sharp contrast to Minnipa, plants initially stunted by the residual Logran treatment recovered to be similar to the control by the time of sampling. DM was increased by P to 283 kg/ha compared to the control. P + Agritone 750 also increased the DM to 305 kg/ha.

Medic nodulation

Number of nodules per plant averaged 6.7 across all treatments, sites and years. Whilst this is low compared to many other legume species, it is in line with expectations for strand medic which is generally regarded as a 'shy nodulator'. Overall, nodule number increased slightly with the addition of P (from 7.1 to 7.3 nodules per plant) and decreased with the application of Agritone 750 Late (7.1 to 6.7 nodules per plant). This herbicide treatment also increased the percentage of ineffective nodules from 42 to 57%.

2015

At Piednippie, Agritone 750, Ecopar + Agritone 750 and urea lowered the number of effective root nodules and increased the number of ineffective nodules. Agritone 750 Late also increased the number of ineffective nodules compared to the control. P increased the number of effective lateral root nodules, medic shoots and root biomass, and lowered the root health score to 4.1 compared to the control's 6.0 (the lower the score, the healthier the root). The Ecopar + Agritone 750 mix increased the root health score to 7.8.

At Pinbong the number of effective nodules per plant was reduced by Broadstrike, Agritone 750, urea and Ecopar + Agritone 750. These treatments, apart from Broadstrike, resulted in a corresponding increase in the number of ineffective nodules. The Ecopar + Agritone 750 treatment produced the highest number of ineffective nodules with 2.7 compared to the control's 0.9.

2016

At Piednippie, Agritone 750, LVE Agritone and LVE Agritone + Verdict all increased the total number of nodules per plant compared to the control's 7.3. However, these increases were all associated with an increase in the number of ineffective nodules per plant, possibly indicating that the plants' response to the herbicide stress was to produce more nodules to compensate for those that were not working. Agritone 750 and Agritone 750 Late, also increased the number of ineffective nodules per plant compared to the control.

At Pinbong, Agritone 750, Agritone 750 (2) and LVE Agritone all increased the total number of nodules per plant compared to the control's 8.9, however these treatments also increased the number of ineffective root nodules, similar to the results at Piednippie. This may explain why the total number of effective nodules was not affected by any of the treatments.

2017

At Minnipa the total number of nodules per plant averaged 6.3. Nodulation and root weights were not affected by any treatment. Levels of root disease were reasonably low (4.5 out of 15) and did not differ between treatments.

At Piednippie the total number of nodules per plant averaged 7.4. Although treatments had no effect on total nodule number per plant, there were treatment differences in the effectiveness and distribution of nodules on the roots. Generally, LVE Agritone Early and LVE Agritone Late increased the proportion of ineffective nodules to >90%. Similar to Minnipa, the levels of root disease at Piednippie were reasonably low with a score of 5.6 out of 15, and did not differ between treatments.

Nitrogen fixation

2015

At Piednippie the control averaged 9 kg of fixed N/ha in shoots. The amount of fixed N was increased by P to 23 kg/ha. Agritone 750 Late decreased the amount of fixed N to 5 kg/ha. 65% of the N present in medic tops had been fixed.

At Pinbong the control averaged 21 kg of fixed N/ha, however the amount of fixed N/ha did not differ between treatments. More than 90% of the N present in the medic tops had been fixed.

2016

At Piednippie the two controls averaged 25 kg of fixed N/ha. Agritone 750 Late reduced this to 17 kg of fixed N/ha. Urea reduced the amount of N fixed to 15 kg/ha. P at 10 kg/ha increased the amount of fixed N to 39 kg/ha. 83% of the N present in medic tops had been fixed.

Table 1 Total soil mineral N (0-60 cm) kg N/ha in the autumn following the medic trial

2016		2017		2018	
Piednippie	Pinbong	Piednippie	Pinbong	Piednippie	Minnipa
89	101	50	32	48	31

At Pinbong the two controls averaged 23 kg of fixed N/ha. Agritone 750 Late reduced the amount of fixed N to 13 kg/ha. Applying urea to the medic reduced the amount of fixed N to only 7 kg/ha. At Pinbong 92% of the N present in medic tops had been fixed.

2017

At Piednippie the control averaged 2.8 kg of fixed N/ha. P + Agritone 750, P + Tigrex and P, all increased the amount of N fixed/ha to 5.9 kg N/ha, 5.2 kg N/ha and 6.2 kg N/ha respectively. This was probably due to the P producing more biomass, as the amount of N fixed/t DM did not significantly differ from the control for any treatments. The average amount of N fixed in medic tops was 3.9 kg N/ha, and 86% of the N present in medic tops had been fixed.

At Minnipa the control averaged 5.1 kg of fixed N/ha, however the amount of fixed N/ha and the amount of N fixed/t DM did not differ between treatments. The average amount of N fixed in medic tops was 4.1 kg N/ha, and 44% of the N present in medic tops had been fixed.

Soil mineral nitrogen

The trial sites were sampled for mineral N in the root zone in March following each trial year. In 2016, 2017 and 2018, soil mineral N was not affected by treatments in the 0-10 cm or the 10-60 cm zones at any of the trial sites (Table 1).

Wheat

In both 2016 and 2017, the previous years' medic treatments had no effect on plant emergence, late dry matter, or grain protein of the wheat crop sown on the trial sites.

At Pinbong in 2017, the previous year's applications of LVE Agritone + Verdict and Agritone 750 (2) decreased the yield of wheat, even though these treatments had not affected the amount of N fixed by the medic in 2016, nor the amount of soil N present in March 2017.

What does this mean?

One of the reasons for uncertain N contributions from medic pastures could be the late applications of herbicides commonly used for weed control in these pastures. Products such as Agritone 750 at label rates can stunt medics and substantially reduce N fixation. One proviso to this conclusion is that many EP farmers use rates of these herbicides well below recommended label rates, so impacts of these applications may be smaller in commercial situations.

The large benefits of P applications to medic growth and N fixation reinforce the value of sound P nutrition to optimise medic performance.

In general, biomass production and total N contribution from the medic pastures has been low in the establishment year, and likely explains why no significant differences in soil mineral N were able to be measured in the years following the medic pasture. In regenerating medic pasture the treatment impacts on medic growth and N fixation would be greater due to the increased biomass, and therefore likely to have greater impacts on the following cereal crop.

These trials have shown that applying P when establishing medic pastures can substantially increase their productivity, whereas using certain herbicides can significantly damage them, by reducing their ability to grow, maintain effective nodules and fix nitrogen. Herbicides are an essential part of weed management, but their negative effects on medic pasture growth for N production and livestock feed, must be considered from a whole farming systems perspective in relation to the value of the weed control they provide.

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