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Identifying the causes of unreliable nitrogen fixation by medic based pastures

RESEARCH

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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

Location
Piednippie - Brent Cronin & Family
Rainfall
Av. Annual: 379 mm
Av. GSR: 304 mm
2017 Total: 247 mm
2017 GSR: 199 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)

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.**
- **Applying a full label rate of Agritone 750 (late) decreases pasture production and N fixation in actively growing medic pastures.**
- **Residues of the herbicide Logran can severely stunt medic growth.**

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 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 has become apparent that some of these pastures are not providing sufficient N reserves (farmer observations) for the following cereal crops, even where the medic has been quite productive. Thus, the longer term decline of protein levels in cereal crops are of concern. Medic pastures are now often sprayed with a range of herbicides and pesticides, both to ensure their productivity as pasture for livestock, and that 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 mostly reports on the third and final year of these trials. For a detailed summary of the results from the first and second years, please refer to the Eyre Peninsula Farming Systems (EPFS) Summary 2015 p209 and EPFS Summary 2016 p142 respectively.

Location
Pinbong - Greg Scholz & Family
Rainfall
Av. Annual: 321 mm
Av. GSR: 227 mm
2017 Total: 307 mm
2017 GSR: 150 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

How was it done?

Two replicated field trials were established on EP in 2017. One on a red sandy loam, representative of typical Mallee environments in SE Australia (Minnipa Agricultural Centre Airport) and the other on a grey highly calcareous sandy soil (Brent Cronin's property at Piednippie).

The 2017 medic trials were dry sown with inoculated Herald strand medic at 10 kg/ha, on 6 June at Minnipa and 7 June at Piednippie. All nutrition treatments were applied at sowing (Table 1). Treatments to simulate herbicide residues were imposed immediately after sowing.

The early post emergent herbicide treatments were applied when the medic plants reached their third trifoliate leaf stage on 21 August (Minnipa) and 24 August (Piednippie). Due to the lack of early season rainfall and poor seasonal conditions this was much later on the calendar than when these herbicides would normally be applied in an average season.

The late herbicide treatments were applied when the medic plants were 5-7 cm in diameter on 11 September at both sites. At the Piednippie site only, there was an extra treatment of Agritone 750 Late at 100 ml/ha.

Plots were sampled on 15 September (Piednippie) and 18 September (Minnipa) to determine dry matter (DM) as an estimate of medic productivity. A further sampling of medic plants and roots was done on 5-6 October for assessment of nodulation and ^{15}N fixation by the natural abundance method. Soil mineral N will be measured in autumn 2018 to estimate the impact of treatments on soil N reserves for the following crop. Plots were kept weed free as much as possible.

Table 1. Treatment details in 2017.

Treatment	Active ingredient	Chemical group	Application rate (units/ha)
Nutrition			
Phosphorus	Phosphoric acid		10 kg P
Phosphorus + Tigrex	Phosphoric acid 250 g/L MCPA as the ethylhexyl ester; 25 g/L Diflufenican	F I	10 kg P 100 ml +200 ml *wetter
Phosphorus + LVE Agritone	Phosphoric acid 570 g/L MCPA as the 2-ethylhexyl ester	I	10 kg 250 ml + 200 ml *wetter
Phosphorus + Late Agritone 750	Phosphoric acid 750 g/L MCPA (as dimethylamine salt)	I	10 kg P 200 ml
Zinc	Zinc Sulphate		2 kg Zn
Herbicide residues			
Intervix	33 g/L Imazamox; 15 g/L Imazapyr	B	45 ml
Logran	750 g/kg Triasulfuron	B	1.75 g
Lontrel	300 g/L Clopyralid (as triisopropanolamine salt)	I	7.5 ml
Post emergent herbicides			
Tigrex Early	250 g/L MCPA as the ethylhexyl ester; 25 g/L Diflufenican		100 ml + 200 ml *wetter
Tigrex Late	250 g/L MCPA as the 2-ethylhexyl ester; 25 g/L Diflufenican	F I	100 ml +200 ml *wetter
LVE Agritone Early	570 g/L MCPA as the 2-ethylhexyl ester	I	250 ml + 200 ml *wetter
LVE Agritone Late	570 g/L MCPA as the 2-ethylhexyl ester	I	250 ml + 200 ml *wetter
Agritone 750 Early	750 g/L MCPA (as dimethylamine salt)	I	200 ml
Agritone 750 Late	750 g/L MCPA (as dimethylamine salt)	I	200 ml
Control	Inoculated with rhizobia		

**Wetter = BS1000*

What happened?

Due to the dry start, the medic was sown nearly a month later than in the two previous years, and took nearly another month to establish. Growth continued to be slow, with the growing season rainfall (GSR) at Minnipa measuring only 155 mm, with most of that rain falling in July and August. At Minnipa Airport and Piednippie, the mean site plant densities were 223 plants/m^2 and 218 plants/m^2, respectively. 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 sowing to simulate herbicide residues in the soil, was causing stunted 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, phosphorus and zinc 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, shoot biomass (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, shoot biomass (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. Biomass was increased by P to 283 kg/ha compared to the control. P + Late Agritone 750 also increased the shoot biomass to 305 kg/ha.

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 (based on a visual score) 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 decreased the proportion of effective nodules. 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.

Plant nitrogen (2016 trial results)

In 2016 the amount of N in medic shoots derived from fixation was estimated using the ^{15}N natural abundance method. At Pinbong, Agritone 750 Late and urea both decreased the amount of fixed N. The two controls averaged 23 kg of fixed N/ha, but the late application of Agritone 750 reduced this to 13 kg of fixed N/ha. Applying urea to the medic reduced the amount of N fixed to only 7 kg/ha. Urea also decreased the amount of N fixed per tonne of DM.

At Piednippie Agritone 750 Late and urea also decreased the amount of fixed N. The two controls averaged 25 kg of fixed N/ha, but the application of Agritone 750 Late reduced this to 17 kg of fixed N/ha. Urea reduced the amount of fixed N to 15 kg/ha. At Piednippie the addition of 10 kg/ha of P increased the amount of fixed N to 39 kg/ha.

The percentage of N in medic tops which had been fixed was 92% at Pinbong and 83% at Piednippie. At Pinbong the average amount of N fixed in tops was 20 kg N/ha; similar to the amount measured in 2015, whereas at Piednippie, the average amount of fixed N (kg/ha) more than doubled in 2016, from 11 kg/ha to 25 kg/ha. The 2017 results are not yet available.

Soil mineral nitrogen

The 2016 trial sites were sampled for mineral N in the root zone in March 2017. Soil mineral N was not affected by treatments in the 0-10 cm or the 10-60 cm nor the combined 0-60 cm soil zone, at both sites. Similarly, there were no treatment effects on soil mineral N in 2016, after the 2015 medic trials. The average total mineral N (0–60 cm) was 32 kg N/ha at Pinbong and 50 kg N/ha at Piednippie in March 2017. These totals are substantially lower than those measured in the autumn 2016 following the 2015 trials. In 2016, Pinbong and Piednippie measured 101 kg N/ha and 89 kg N/ha, respectively. The 2017 results are not yet available.

Wheat

In the 2017 season, the 2016 medic trial sites were sown with Scepter wheat on 18 May (Pinbong) and 7 June (Piednippie) at a rate of 60 kg/ha. At Pinbong the average yield was 1.36 t/ha, average protein was 10.8% and the average screenings were 7.4%. At Piednippie the average yield was 0.79 t/ha, average protein was 10.8% and the average screenings were 7.4%. The previous year's medic treatments had no effect on plant emergence, late dry matter, or grain protein. At Pinbong the 2016 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.

In 2016, the wheat sown onto the 2015 medic trial sites also had no differences in yield, protein and screenings.

What does this mean?

The dry start this year meant that the medic was sown late, was slow to emerge and produced less than 500 kg/ha shoot dry matter. Continuing low rainfall and high spring temperatures meant that the medic was stressed at the time of the nodulation assessment, which may have increased the numbers of ineffective nodules recorded. At Minnipa the plants were podding and their nodules were generally senescent, so very few nodules were recorded as effective, making it difficult to discern herbicide effects. At Piednippie plants were less mature with some treatment effects on nodulation measured.

As shown in the previous years' trials, P increased medic growth. While the increased biomass would have been beneficial to grazing, this year it did not appear to provide any benefit to N fixation in terms of nodulation, although we are yet to receive the N fixation results.

At Minnipa residual Logran severely stunted early medic growth, with the plants never recovering. In contrast to previous results, the post emergent herbicides had no effect on medic productivity, almost certainly due to the dry conditions and the plants not actively growing. Piednippie received extra early rainfall which would have increased the activity of soil microbes, allowing them to break down the Logran residue. The extra rain may have washed the residues down through the sandy soil, hence the Logran affected medic seedlings were able to recover. LVE Agritone applied early and late decreased the percentage of effective nodules at Piednippie, but this percentage was already very low on the controls. Therefore, we can conclude that in a dry growing season, when medic plants are already moisture stressed, herbicides will have little impact on medic productivity and N fixation.

Regardless of seasonal conditions, the management of newly established medic pastures with respect to herbicides and fertilisers, appears to have no influence on the yield and protein level of the wheat crop in the following year.

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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