**Contribution of pasture legumes to soil mineral nitrogen in northern Victoria**

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## ABSTRACT

Annual and perennial pasture legumes were established in 1998 at Elmore in north central Victoria and Speed in the Victorian mallee to investigate the effects of site and legume species on soil mineral nitrogen and legume dry matter production. The pasture species evaluated included Pioneer L34 lucerne (*Medicago sativa*), Gosse subterranean clover (*Trifolium subterraneum* ssp. *yanninicum*), Herald strand medic (*Medicago littoralis*) and annual ryegrass (*Lolium rigidum*) as the non-legume control. At Elmore the lucerne and subterranean clover pastures produced more legume dry matter than the medic pasture, demonstrating that lucerne and subterranean clover were more suited to north central Victoria. At Speed the opposite occurred, in that the medic pasture produced more legume dry matter than either the subterranean clover and lucerne pastures, confirming that medics were better adapted to north west Victoria. Unlike annual legumes, lucerne's year round growth meant that available nitrogen did not accumulate in the soil profile.

## KEY WORDS

Legume dry matter production, strand medic, subterranean clover, lucerne.

## INTRODUCTION

In southern Australia, pastures based on annual legumes have long formed an integral part of mixed farming enterprises. Annual legume pastures not only provide quality herbage for grazing animals, but also help to boost soil fertility and disrupt disease and pest cycles before the next cropping phase. More recently, the benefits to subsequent crops from lucerne providing inputs of fixed nitrogen and improving soil water use have been reported (10).

The benefits of rotating legumes with crops are well documented. Morrow (7) introduced the concept of clover ley farming in the 1940's after trials at Rutherglen had found increased cereal yields following subterranean clover. These early results were the foundations of today's pasture/crop rotations, recommending the value of a number of years of subterranean clover pastures to increase soil fertility.

This research helped to trigger an era where subterranean clover pastures became widely adopted to boost cereal yields. However by the late 1970's, falling commodity prices and spiralling farm costs placed growing pressures on producers (2). To improve farm income, many broadacre producers increased their cropping enterprises. The comparative profitability of crop production over livestock enterprises encouraged a significant increase in the area under crop production during the 1980's (3).

This shift towards more intensive cropping practices resulted in a serious decline in the legume contents, and management inputs, of pastures grown in rotation with crops. Wilson and Simpson (12) noted that pastures grown in rotation with crops were low in legume content, poorly managed and dominated by grasses and volunteer annual weed species.

Considerable research has been undertaken to identify management strategies that increase legume composition and productivity prior to the cropping phase. Selection of the appropriate legume species adapted to the soil and climatic conditions is one such strategy available to producers. Previous studies (4, 5, 6, 10) have focused on a particular pasture legume and little information is currently available quantifying the effects of different legume species on soil nitrogen under the same climatic and soil conditions.

## MATERIALS AND METHODS

Gosse subterranean clover, Herald medic, Pioneer L34 lucerne and a non-legume control of annual ryegrass were sown at Elmore in north central Victoria ($144^{\circ}37'$E, $36^{\circ}30'$S) and Speed in north west Victoria ($142^{\circ}26'$E, $35^{\circ}26'$S) in April 1998. Each pasture treatment was replicated four times and plots were 20 m x 30 m in area. The lucerne and annual ryegrass pastures were sown at 10 kg/ha, while the subterranean clover and medic pastures were sown at 20 kg/ha. The above-ground dry matter production of each pasture was assessed at 6-8 week intervals, by a composite sample cut from four quadrats (0.25 m x 0.25 m) randomly placed in each plot. Each sample was sorted into legume, grass and broadleaf weeds to determine pasture composition, and then oven dried at $65^{o}$C for 24 hours and weighed. After each dry matter cut, plots were intensively grazed (80 DSE/ha) to a height of approximately 4 cm.

Soil mineral nitrogen was assessed at the autumn break in 1998, 1999 and 2000. At Speed three composite soil cores were randomly collected to a depth of 0.6 m from each plot and divided into two depth increments 0-0.1 m and 0.1-0.6 m. At Elmore in 1998, 10 composite soil cores were collected to a depth of 0.7 m from across the site at the following five depth increments (0-0.1, 0.1-0.2, 0.2-0.3, 0.3-0.5 and 0.5-0.7 m). However, in 1999 and 2000, three composite soil cores were randomly collected from each plot and divided into the reported depth increments. At each depth increment soil cores were weighed to determine total wet weight. A 200 g subsample was taken from each depth increment and oven dried at $105^{o}$C for 24 hours to calculate gravimetric water content and bulk density. A second subsample of 500 g was oven dried at $40^{o}$C for 24 hours, and passed through a 2mm sieve for mineral nitrogen determination. Soil mineral nitrogen (ammonium and nitrate) contents were determined using a modification of the method of Rayment and Higginson (9) where 2M KCl soil extracts were analysed by automated colorimetric procedures using a dual-channel auto analyser.

## RESULTS

In 1998 and 1999 the annual rainfall at Elmore was 19 and 26 mm, respectively, less than the long-term average of 471 mm, whilst at Speed annual rainfall was 44 mm less than, and 89 mm greater than, respectively, the long-term average of 289 mm.

At Elmore in 1998, medic dry matter production was no different (P=0.05) from that of subterranean clover. However, by 1999 the production of the subterranean clover and lucerne were significantly greater than the medic (Table 1). At Speed the opposite ranking occurred, where in both years the medic produced significantly more legume dry matter than either the subterranean clover or lucerne.

**Table 1. Mean cumulative legume dry matter production (t/ha).**

| Pasture species | Elmore | Elmore | Speed | Speed |
|---|---|---|---|---|
| | 1998 | 1999 | 1998 | 1999 |
| Gosse subterranean clover | 2.8 | 2.9 | 0.8 | 2.0 |
| Herald strand medic | 3.3 | 1.0 | 1.4 | 3.6 |
| Pioneer L34 lucerne | [A]1.5 | 3.0 | 0.4 | 1.3 |
| Ryegrass | 0.0 | 0.0 | 0.0 | 0.2 |

| | | | | |
|---|---|---|---|---|
| l.s.d (P=0.05) | 0.6 | 1.0 | 0.3 | 0.9 |

[A]DM production to mid October 1998 only

Two years after sowing, the soil mineral nitrogen content of the Elmore soil was significantly greater under the subterranean clover compared with the lucerne, medic and annual ryegrass pastures (Table 2). At Speed the soil mineral nitrogen content was significantly greater under the lucerne and medic pastures than the annual ryegrass pasture.

**Table 2. Mean soil mineral nitrogen content (kg/ha) prior to and two years after each pasture species was sown.**

| Pasture species | Elmore (0-0.7m) | | Speed (0-0.6m) | |
|---|---|---|---|---|
| | 22.4.98 | 4.5.00 | 23.4.98 | 28.4.00 |
| Gosse subterranean clover | 41 | 122 | 70 | 50 |
| Herald strand medic | 41 | 74 | 50 | 76 |
| Pioneer L34 lucerne | 41 | 84 | 68 | 84 |
| Ryegrass | 41 | 65 | 51 | 42 |
| l.s.d (P=0.05) | | 31 | n.s. | 32 |

The distribution of mineral nitrogen in the soil profile at Elmore after one year of each pasture is illustrated in Figure 1. There were no differences in the amounts of mineral nitrogen present at all depths under the lucerne and annual ryegrass pastures. In contrast there was more mineral nitrogen in the surface 0.1 m of soil under both the subterranean clover and medic pastures than under the lucerne pasture. Significantly higher mineral nitrogen was recorded under the medic pasture compared with the lucerne pasture at 0.2 m depth. Below 0.2 m significantly greater mineral nitrogen was measured under the subterranean clover pasture compared with the lucerne pasture.

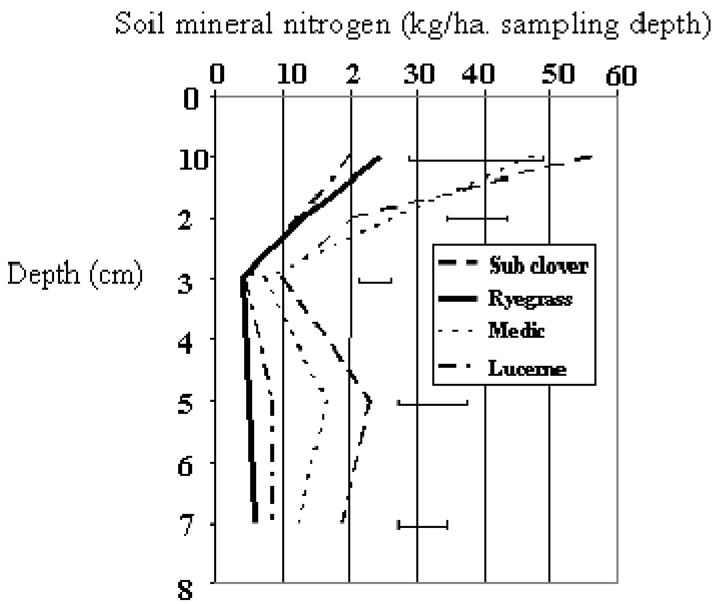


**Figure 1. Distribution of soil mineral nitrogen under different pasture types at Elmore on 24.4.1999. l.s.d (P=0.05).**

## DISCUSSION

In the two years of this study, the medic was the most productive legume at the low rainfall, alkaline soil site in north west Victoria. The poor performance of the second year medic pasture at Elmore may have been due to a high level of hard seededness in the 1998 seed set, resulting in a poor germination density in the second year (T Bolger, pers.comm.). The low dry matter yield of the first year lucerne pasture at Elmore only represented growth up to mid-spring as the late spring and summer growth was not measured. Hirth *et al* (4) have shown that 30-40% of lucerne's annual growth is produced in the mid-spring to early summer period. The second year dry matter yield of the lucerne pasture at Elmore was comparable with that of subterranean clover, which was the most productive legume over the two years of the study at this site. This data demonstrated that both lucerne and subterranean clover were better suited to north central Victoria than north west Victoria.

Increased soil mineral nitrogen in autumn 2000 was measured under the higher yielding legumes at both Elmore and Speed. Peoples *et al* (8) concluded that the quantity of nitrogen fixed by legume pastures is largely influenced by legume yield. Inputs of fixed nitrogen to the soil can be enhanced by the greater production of superior-performing subterranean clover and medic pastures.

The finding at Elmore of less mineral nitrogen in surface soils under lucerne, compared with the annual legumes, is consistent with the findings of other studies in Australia (5, 4). The perennial growth habit of lucerne means that it can extract available nitrogen all year round, and does not allow significant accumulation of soil mineral nitrogen. In both situations, soil mineral nitrogen only begins to accumulate after legumes have senesced, which happens at the end of every growing season for annual legumes, and only after perennial legumes have been killed (5, 4).

The timing of lucerne removal and climatic conditions following can influence soil mineral nitrogen levels available at the sowing of the first grain crop (1). At Elmore, where the lucerne was removed only four weeks prior to sampling, the soil mineral nitrogen levels were equally low under both the lucerne and the annual ryegrass pastures but high under the subterranean clover. However, at Speed the soil mineral nitrogen levels under the lucerne were significantly greater than under the annual ryegrass and subterranean clover pastures, because it was removed in October 1999 and followed by above average rainfall before the soils were sampled.

## CONCLUSION

The reported experiment demonstrates that the medic is better adapted to the low rainfall, alkaline soil of north west Victoria, whilst subterranean clover and lucerne performed better in north central Victoria. Pastures that yielded greater amounts of legume dry matter did not always produce greater amounts of soil mineral nitrogen. Lucerne's year round growth did not allow any soil mineral nitrogen to accumulate. The early removal of lucerne at Speed produced elevated levels of soil mineral nitrogen in the following autumn, whereas the late removal of lucerne at Elmore had no effect.

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