Factors affecting sub clover performance

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KEY MESSAGES

- Soil acidity and residual herbicides may be affecting the ability of sub clover to fix N
- Grazing management practices that favour legume germination, growth and seed set are key to ensure adequate legume content within pastures
- Provision of adequate nutrition, particularly phosphorus and molybdenum will favour legume growth and nitrogen production
- Soil borne diseases in pastures containing old cultivars with poor resistance such as Mt Barker can be holding back pasture production

Keywords: Sub clover, persistence, pasture, soil borne diseases

BACKGROUND

Grazing crops has great potential to improve the feed base of mixed farm systems in South Eastern Australia, with livestock gross margins following suit. The draw-back is the additional risk to crop yields, with a survey of growers across South Australia and Victoria pointing to fear of yield loss as being the number one reason for not grazing crops (Creelman et al, 2015).

The aim of the trial was to investigate the drivers for yield loss under grazing with a view to make grazing crops less risky. It was repeated in 2015 and 2016, with sister trials in the Mallee, eastern South Australia and the Eyre Peninsula under the GRDC project Grain and Graze (SFS00028).

In 2016, Dr Belinda Hackney, DPI NSW, surveyed 240 paddocks containing sub clover across southern Australia. She found 90% of paddocks had inadequate nodulation, with an average nodulation score of 2 out of 8, where a score of 4 is considered adequate (>21 small pink nodules or >3 large pink nodules). The chain between clover and nitrogen production appeared to have been broken.

Sub clover is the most widely planted annual pasture legume in southern Australia. The ability of subterranean clover to ‘fix’ atmospheric nitrogen and increase soil fertility is of immense agricultural importance. It benefits growth of the legume itself, the perennial grass or non-leguminous species in pasture, and of subsequent crops grown in rotation.

It is suggested that biologically fixed nitrogen is the next most fundamentally important biological process after photosynthesis. This is certainly the case in Australia where the majority of soils have inherently low nitrogen status (Nichols, 2017). Subterranean clover fixes approximately 25 kilograms of nitrogen per tonne of herbage dry matter. As a result, it can increase soil nitrogen by approximately 125-200 kg N/ha/year (Nichols & Dear, 2007). Importantly however, if the plant is not fixing nitrogen, it is using it from the mineralised N component and at the expense of other species.

The bottom line is our grazing systems rely on having pastures containing sub clover which is fixing nitrogen.

This report attempts to summarise the main management factors that affect performance of sub clover, so producers can optimise clover content and management.

Management factors affecting sub clover performance

Grazing management

Subterraneum clover is a prostrate growing, self-regenerating annual pasture legume that grows from autumn through to spring and prospers under well managed heavy grazing.
The grazing management for sub clover can be divided into four distinct stages (Nicholson, 2006). These are:

- Over summer
- Following autumn
- Leading up to flowering
- During flowering

**Over summer**

The aim over summer is to encourage the break-down of a high proportion of hard seeds. This is achieved when seeds (including buried seed) are fully exposed to fluctuating soil surface temperatures (hot days, cool nights). Excessive trash or dry material left on the soil surface over the summer-autumn period acts as insulation and prevents the seed from being exposed to these temperature fluctuations. It is recommended that grazing is controlled to leave approximately 1000kg DM/ha at the autumn break. Excessive dry matter or trash not only inhibits the germination of sub clover seed, but trash of some pasture species also produces an allelopathic affect. This is related to a chemical that is washed out of dry plant material, particularly from silver grass. These chemicals are called allelochemicals and they retard germination, root growth and nodulation of sub clover. Grazing dry matter over the summer should reduce most plant residue, but not to the extent that stock start consuming any surface burr, as seed eaten by stock will generally not germinate. Achieving a high level of hard seed breakdown will still result in a buffer of non-germinable seed as a means of self-preservation in the event of a false break.

**Autumn**

At the break of season, deferred grazing until seedlings have 3 true leaves (3-6 weeks after the autumn break) can improve seedling establishment and pasture density. The benefits are often greater in seasons with a late break where the capacity to establish a critical leaf area is reduced. Both surface burr and buried burr will germinate, however the surface burr is more likely to dry out and die if there are inadequate follow up rains. Surface burr are also more likely to be pulled out by grazing, as their roots are not well anchored compared with plants from buried burr.

**Leading up to flowering**

The objective over winter and into early spring is to maximise leaf production. Sub clover’s prostrate growth means that it is adapted to and performs well under frequent heavy grazing during the winter and early spring, when an ideal sward height of 5cm or less is maintained. This hard grazing greatly increases seed production as it increases the number of leaves on a sub clover runner. Each time the plant is grazed, new leaves are produced on the runner creating a potential site for a new flower. Variation in seed production is related to total dry matter production, hence more leaves means more yield. Hard grazing until the onset of flowering encourages burr burial, whilst lenient grazing, which allows the stand to become very leafy, results in a higher proportion of burr being set on the soil surface. Buried burr tends to be larger, have a higher viability and become soft more slowly. The amount of seed buried is influenced by choice of variety and by grazing management.

**During flowering**

Sub clover needs to capture light to create energy to fill the growing seed. This means that the plant needs to maintain some leaf. Therefore, during the flowering period, grazing should be reduced but not removed, a difficult balancing act. Lax grazing will tend to favour grasses and shade out the sub clover, whilst excessive grazing after flowering may remove flowers. The target should be to keep dry matter at or below 2000 kg/DM/ha. Sub clover growers aim to avoid defoliation after 30-50% of flowering has occurred (October), but for most farmers reduced grazing over spring will suffice.

**The use of herbicides**

Herbicides are an important tool in controlling weeds in pastures. However, many broadleaf herbicides and some grass herbicides severely retard sub clover growth. This effect is most pronounced in winter as recovery is slow due to cold temperatures, although most clover plants will recover in spring. When considering broadleaf herbicide application, particularly MCPA and 24D Amine, it is recommended to apply these herbicides at least six weeks prior to flowering so as not to depress clover seed set, so ideally in late autumn or winter. Ballard (2017) reports a potential issue with MCPA affecting symbiosis with rhizobia when applied late in season in medics and some evidence to suggest low rates used early in the growing season will minimise potential damage.

The use of herbicides during flowering ideally should be avoided. Spray topping, either with glyphosate or Sprayseed (paraquat/diquat), is not recommended as either treatment will affect flowering or the maintenance of green leaf (which is needed to fill the seed). Generally, paraquat being a contact herbicide is considered safer for clover seed production than the systemic acting glyphosate. Dr Belinda Hackney suspected residual Group B herbicides carried over from cropping to be one of the main
offenders for poor nodulation of sub clover identified in her survey. The herbicides clovers are sensitive to appear to be sulfonyl ureas (e.g. Ally), clopyralid (Lontrel, Titan) and there is some effect on particular legume species with Sakura. Chlorsulfuron and triasulfuron methyl (both sulfonyl ureas) have also been implicated in causing poor nodulation in WA (Ballard, 2017). Sulfonyl ureas cause root pruning, which presents as glassy root systems with stubby or non-existent root hairs and the soil does not cling to the root system. Ally (metsulfuron methyl) is frequently used in the selective removal of onion grass within established pastures and although these pastures need to be re-sown with clover, these findings raise questions about its effects on the nodulation of the new sown clovers. Belinda observed there was also root pruning around the crown of the root system (in a band) and then a healthy root system below that point, however with much reduced or absent nodulation. Generally, most rhizobia occur in the top 5 cm of soil and nodules in this area are first formed and the most productive, so when these are lost there are greater consequences for N-fixation (personal communication Belinda Hackney). Different cultivars have different tolerances to these herbicides with Balansa clover being very sensitive, but pulses having better tolerance. Testing has shown that levels of 1/100th of label rate of sulfonyl ureas will affect sub clover nodulation.

**Soil acidity**

Sub clover has good tolerance of soil acidity compared to most other legumes. The rhizobia we inoculate the plant with however do not. The ideal soil pH for the Group C rhizobia used is 5.5-7.0 (CaCl2). Within this range, efficiency and nitrogen production is highest. Between pH 5-5.5 efficiency drops off and below pH 5.0 the effect is severe. Ron Yates (DAFWA/Murdoch rhizobiologist) presents it in his talks as a green, amber, red traffic light system.

Dr Belinda Hackney found 50% of paddocks surveyed had less than pH 5.0 (CaCl2), which would severely impact Group C rhizobia performance. Therefore, a major reason behind poor nodulation of sub clover was soil acidity. Belinda suspected there was also a compounding effect of both residual herbicides and soil pH at play. We inoculate sub clover to get better nitrogen fixation and the Group C rhizobia are in the order of 50% better at fixing N compared to their native rhizobia counterparts (Ballard, 2017). The important thing here to remember is that the Group C rhizobia are less tolerant of low pH than their associated native rhizobia. They are also outnumbered, and Ross Ballard (SARDI) believes they generally last approximately three years before being overrun by native population.
Although sub clover is considered an acid tolerant plant, if aluminium levels exceed 12% exchangeable aluminium, then root hairs will be affected and any surviving rhizobia will struggle to nodulate the damaged roots. It is generally at low pH (< 4.8) that aluminium becomes more soluble and can start to damage root systems. Also at low pH, molybdenum which is a key nutrient for sub clover nitrogen fixation becomes less available.

**Fertility**

Sub clover has many nutrient requirements, of which phosphorous (P) is the most important. Graziers would be familiar that the Olsen P target for pastures achieving 95% of maximum production is 15 mg/kg and this is due to sub clover’s high requirement of P compared to perennial grasses which require an Olsen P of 12 mg/kg. Research also shows that soil phosphorous affects the phosphorous content of the seed, with higher phosphorus seeds germinating and growing more rapidly as seedlings than sub clover plants that formed burrs on lower fertility soils.

Soil calcium also plays a critical role in creating viable seeds, with seed production shown to be severely limited by exchangeable calcium levels <3 meq/100 gm. A desirable level is above 5 meq/100 gm. The use of lime or gypsum will ensure adequate soil levels are achieved if deficient.

Molybdenum (Mo) is important for the Rhizobium bacteria to fix atmospheric nitrogen (N2) and therefore legumes have a higher requirement for Mo than non-legumes. A guide to the optimum level is shown in table 1 (Warn 2017). Rob Norton (IPL) recommends the use of fertiliser test strips to determine responsiveness, as responses have been found at 0.4 and 0.5 mg/kg from whole plant analysis (Norton 2017). Rob said soil analysis has not been a satisfactory method for diagnosis of molybdenum deficiency, but it is still available through commercial soil testing services. Special analytical techniques are required so the low concentrations can be accurately determined.

**Table 1. Desirable levels of trace elements required by sub clover from a tissue test**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Desired level for sub clover</th>
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<tbody>
<tr>
<td>Molybdenum mg/kg</td>
<td>&gt;0.4</td>
</tr>
<tr>
<td>Copper mg/kg</td>
<td>5-30</td>
</tr>
<tr>
<td>Zinc mg/kg</td>
<td>15-50</td>
</tr>
<tr>
<td>Cobalt mg/kg</td>
<td>&gt;0.04</td>
</tr>
<tr>
<td>Boron mg/kg</td>
<td>20-100</td>
</tr>
<tr>
<td>Iron mg/kg</td>
<td>50-400</td>
</tr>
<tr>
<td>Manganese mg/kg</td>
<td>25-300</td>
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</tbody>
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Figure 2: Prolific clover growth at Bamganie lime trial indicating a molybdenum response in the lime treatment versus the control.

Liming acid soil will generally make molybdenum more available and for this reason applying lime and molybdenum fertiliser in the same year is unadvised as it may lead to levels of molybdenum within plants that is harmful to stock. In some cases applying molybdenum and sulfur may induce a copper deficiency in livestock where marginal copper conditions exist. In these situations copper is also applied.
Sub clover has shown good responses to Boron in Australia and in particular seed production (Price, 2012). Plant availability of boron is optimum between pH 5.0 and 7.0. Higher or lower values can reduce boron uptake by the plant. Although application may only slightly improve dry matter production, seed set can be significant and is therefore an area for investigation if persistence of sub clover is an issue (Price, 2012).

Cobalt is necessary for nitrogen fixation by sub clover, but there are few recorded reports of deficiencies.

**Susceptibility to soil borne diseases**

Recent studies by Professor Martin Barbetti (University of WA) found potentially significant production losses of sub clover at germination and post emergence due to soil borne fungal root diseases, particularly during the autumn-winter period where feed is often in short supply. He estimated potential losses in the autumn-winter period of approximately 23% (Barbetti, 2017). The study found that four main pathogens were at play, Pythium, Phytophthora, Rhizoctonia and Aphanomyces. All reduce potential seed germination and cause root roots, creating bonsai type plants. These pathogens become expressed under different environmental conditions, e.g., Phytophthora under wet soils and high soil temperatures, Rhizoctonia under cold conditions and dry soils (see Table 2). Pythium, Phytophthora and Aphanomyces pathogens are potentially favoured with late season breaks when temperatures are cooler and can further exacerbate feed shortages. Paddock survey work displays plenty of evidence that these pathogens commonly exist. Sub clover cultivars vary in their resistance to these diseases and there are concerns that breeding resistance into new clovers has become a low priority. Some cultivars have built up field tolerances, but the majority of older cultivars are thought to have little resistance. Information on which cultivars are resistant is not readily accessible, although Barbetti identified that Trikkala had shown disease resistance in Victoria, and Clare in South Australia.

<table>
<thead>
<tr>
<th>Pythium</th>
<th>Rhizoctonia</th>
<th>Phytophthora clandestina</th>
<th>Aphanomyces trifolii</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loam soil, low temperatures and high moisture</td>
<td>Cool seasonal conditions; especially under relatively drier soil conditions and in nutritionally impoverished sandy soils</td>
<td>High moisture levels and warm temperatures</td>
<td>Cold temperatures and wet and waterlogged conditions</td>
</tr>
</tbody>
</table>

Work by the Grassland Society of Southern Australia’s Central Range’s branch, highlighted the affects these diseases can have on production. The group had been concerned that despite good fertility levels, pastures were not performing. They found significant disease present in some paddocks but not in others and they also found variable treatment responses to the application of fungicide spray. In a poor year (2014), in a paddock containing Mr Barker sub clover they increased autumn and winter pasture production by 800 kg DM/ha. In a good year (2016) however, there was little effect on another site which contained Trikala.

Breeding of disease resistance in sub clover appears to be the best form of defence. The most cost-effective on-farm chemical treatments and cultural practices for control of root disease in subterranean clover pastures, developed from Barbetti’s research was:

- Cultivating soil to reduce pathogens and subsequent root disease impacts on productivity
- Applying a registered fungicide seed coating prior to replanting, or fungicide sprays on regenerated pastures (use test strips to gauge responses).
- Ensuring adequate soil and plant nutrition, through strategic fertiliser management, to enable better root and shoot growth even when disease is severe.
- Choosing varieties that perform best in your area. Sow a mixture of clovers as an insurance policy.
- Using a rotational grazing system that allows more plant growth and in turn improves root development, even where disease is severe.

SARDI now offer Predicta B tests which can confirm the type of pathogen present but cannot yet tell us the level of infection or how much damage they will do. These tests might cost up to $400, although it is hoped prices will come down as testing increases. Healthy sub clover plants will have lots of whitish tap and lateral roots. Any blackened roots, or lack of branching suggests disease presence.

**Insect pests**

Red legged earth mite [RLEM] are the major pest of subterranean clover, particularly at the seedling stage. Farmers should spray to protect new sowings and when high RLEM infestations.
All older cultivars are susceptible to RLEM as seedlings. However, new cultivars have been released with increased cotyledon resistance to RLEM. These cultivars include:

- Rosabrook
- Narrikup
- Bindoon
- Tammin
- Forbes

Field studies have shown these cultivars have higher seedling densities in regenerating pastures than similar older cultivars, resulting in increased autumn-winter production. However, the resistance is not absolute. Strategic management decisions based around pest management should be integrated at sowing to ensure good establishment and in regenerating pastures when RLEM densities are high (Nichols, 2017). RLEM’s can also greatly reduce seed set. The mites damage the flower rather than the leaf and the potential seed yield created by appropriate grazing earlier in the year can be undone by inadequate pest control. Other major pests to subterraneum clover include lucerne flea, blue-green aphid and blue oat mite.

**Cultivar selection**

It is critical to select suitable cultivars for both soil type and rainfall to optimise pasture performance and to ensure sub clover’s persistence. There are 6 primary aspects to take into consideration when selecting a sub clover cultivar. These includes: sub species, flowering time, oestrogen levels, hard seededness, disease and pest resistance.

One of the most important characteristics that determines cultivar fit is flowering time. This can ensure the plant can flower and set seed within the growing season, before rainfall runs out. Information on this topic will be made available in subsequent publications.

**REFERENCES**


Hosking WJ (1986) Trace elements for pastures and animals in Victoria. Published by Department of Agriculture and rural affairs.


