Growing biserrula to improve grain and livestock production

Angelo Loi
Natalie Hogg
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Diana Federenko

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Growing biserrula to improve grain and livestock production
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Growing biserrula to improve grain and livestock production

Angelo Loi, Natalie Hogg, Brad Nutt, Clinton Revell and Diana Fedorenko
Department of Agriculture and Food, Western Australia
This publication was funded by Pastures Australia and brings together 15 years of research on biserrula in Western Australia. Major funders of the research were the Centre for Legumes in Mediterranean Agriculture (CLIMA) of The University of Western Australia and the National Annual Pasture Legume Improvement Program (NAPLIP). NAPLIP was a collaboration between Grains Research and Development Corporation (GRDC), Australian Wool Innovation (AWI), Commonwealth for Scientific and Industrial Research Organisation (CSIRO) and all states’ Departments of Agriculture. Contributions were also made by the Centre for Rhizobium Studies (CRS) of Murdoch University, The University of Adelaide and the Rural Industries Research and Development Corporation (RIRDC).

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Thanks to Mike Davies for photographic materials and Femme Roberts for coordinating graphic design and printing.
*Biserrula pelecinus* is a new genus of pasture legume which was developed for commercial agriculture by a team of Perth-based legume pasture scientists in the early 1990s. Biserrula is an annual pasture legume that is found in natural grasslands of the Mediterranean Basin, frequently on acidic soils derived from granite. It was this feature that first caught the eye of researchers who were attempting to develop species that could tolerate the soil stresses of acidity and low moisture-holding capacity. These stresses are common in WA and when they occur together they are problematical for the survival of annual medics and clovers. Biserrula has subsequently been shown to possess a number of important features that give it advantages over the traditional pasture species in mixed farming systems.

Biserrula can nodulate reliably upon acidic, sandy loam soils, and as such can be sown with confidence on soils where annual medics fail to nodulate. A major reason for this is that biserrula has very specific acid-tolerant nodule bacteria (rhizobium) that survives well and colonises these soils. Biserrula also has a root system that rapidly penetrates to depth. This allows it to extract water from deeper in the soil profile than many other annual species. One consequence of this is that biserrula can extend the length of the growing season by accessing deep moisture. This characteristic also gives it some protection during dry autumn conditions, because the tap root is rapidly developed. This rooting characteristic allows it to be sown on soils that are too dry for reliable production from annual clovers.

Further to these attributes, biserrula produces large quantities of hard (impermeable) seeds. The seasonal and annual patterns of seed softening ensure the soil seed bank of biserrula is one of the most resilient of all pasture legumes so far studied. This characteristic makes it ideally suited to intensive cropping systems as enough seed is produced in one season to grow a productive biserrula pasture after as many as three consecutive grain crops. Although the seeds are produced above ground, like medics, biserrula can be grazed in much the same way as medics and subterranean clover as there is an abundance of feed at the time of season when the pods are presented to the animals. Further, a large amount of the mature seed will pass intact through the digestive tract.

Biserrula is an excellent source of biological nitrogen for subsequent crops and can also play an important role in weed management systems. The latter attribute arises because the plant is less palatable than most weeds during spring, so the weeds are selectively removed. With sowing rates of around 5 kg/ha biserrula is one of the cheapest pasture legumes to establish. Biserrula can be distinguished from serradella because it has distinctive fern-like leaves, pale purple to blue flowers and a serrated pod containing up to 20 small yellow seeds.

The two cultivars of biserrula currently available, Casbah and Mauro® differ by several weeks in maturity, allowing the species to be grown across environments with annual rainfall between 325–700 mm.
This management package consolidates the technical information about growing biserrula and documents a number of case studies where growers have successfully incorporated biserrula into their farming systems. Key features include establishment of biserrula, grazing management—particularly to reduce the risk of photosensitisation in sheep—value to subsequent crop production and economic impact.

The manual is intended to be a practical guide for farmers and their advisers to assist them in making decisions about the value of biserrula in their farm business and how to optimise the management of biserrula to ensure potential benefits are realised.

The effort of all the contributors to combine the information in an easy-to-read document is to be commended.

Prof John Howieson
Director
Centre for Rhizobium Studies
Murdoch University
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Description of biserrula

Key messages
- Casbah and Mauro® are the first commercial cultivars of biserrula (*Biserrula pelecinus*) worldwide.
- The descriptions of the cultivars differ as specific traits of wild populations were selected to fit cropping rotations of different intensity.

Climate adaptation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Casbah 325–500 mm</th>
<th>Mauro® 450–700 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall range</td>
<td>Moderate-high in comparison with other annual pastures</td>
<td></td>
</tr>
<tr>
<td>Drought tolerance</td>
<td>Sensitive, frost will reduce seed production</td>
<td></td>
</tr>
<tr>
<td>Frost tolerance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Origin

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Casbah</th>
<th>Mauro®</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed and rhizobium collection</td>
<td>By P Beale, A Lahlou and M Bounejmate in Morocco in 1991</td>
<td>By A Loi, SJ Carr and M Porqueddu in Sardinia in 1995</td>
</tr>
<tr>
<td>Development and selection</td>
<td>By A Loi, JG Howieson and SJ Carr at the Cooperative Research Centre for Legumes in Mediterranean Agriculture (CLIMA)</td>
<td>By A Loi at CLIMA and field tested within the National Annual Pasture Legume Improvement Program (NAPLIP)</td>
</tr>
<tr>
<td>Release</td>
<td>1997</td>
<td>2002</td>
</tr>
</tbody>
</table>

Soil adaptation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Casbah</th>
<th>Mauro®</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil type</td>
<td>Loams and clay loams</td>
<td>Gravely and loamy sands</td>
</tr>
<tr>
<td></td>
<td>Sand over clay</td>
<td></td>
</tr>
<tr>
<td>pH (calcium chloride)</td>
<td>4.2–7.5</td>
<td></td>
</tr>
<tr>
<td>Waterlogging tolerance</td>
<td>Nil</td>
<td></td>
</tr>
<tr>
<td>Salt tolerance</td>
<td>Nil</td>
<td></td>
</tr>
<tr>
<td>Aluminium tolerance</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>Rhizobium</td>
<td>Biserrula specific</td>
<td></td>
</tr>
</tbody>
</table>
## Description of biserrula

### Plant traits

<table>
<thead>
<tr>
<th>Form</th>
<th>Colour</th>
<th>Shape</th>
<th>Weight</th>
<th>Seeds per pod</th>
<th>Type</th>
<th>Growth cycle</th>
<th>Flower Colour</th>
<th>Roots Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed</td>
<td>Yellow</td>
<td>Heart-like</td>
<td>Casbah = 1.2 mg</td>
<td>Casbah = 20 seeds</td>
<td>Aerial</td>
<td>Annual</td>
<td>Pale purple to blue</td>
<td>2 m or longer in unrestricted soils</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mauro = 1.3 mg</td>
<td>Mauro = 15 seeds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pod</td>
<td>Brown (fully matured)</td>
<td>Flat with serrated edges, soft texture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cotyledons</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaf</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flower</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roots</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Development

- **Seedling emergence-flowering**
  - Casbah: 100–105 days
  - Mauro: 115–120 days
- **Flowering-pod maturity**: 4 weeks
- **Hardseededness**: Casbah has a higher proportion of hard seeds than Mauro.
- Both cultivars have slow seasonal and annual patterns of seed softening.

---

Growing biserrula to improve grain and livestock production
**Productivity**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter production</td>
<td>5000–7000 kg/ha is typical. Over 11 000 kg/ha recorded in stands managed for seed crops</td>
</tr>
<tr>
<td>Seed yield</td>
<td>300–1500 kg/ha (depending on total dry matter and harvesting method)</td>
</tr>
<tr>
<td>Feed availability</td>
<td>Earlier than subclover as seedlings can survive false breaks. Extended by up to 4 weeks at the end of the growing season compared to subclover</td>
</tr>
<tr>
<td>Feed palatability</td>
<td>During the green feed period, stock can preferentially graze weed species out of the biserrula pasture</td>
</tr>
</tbody>
</table>

**Nutritive value**

<table>
<thead>
<tr>
<th>Component</th>
<th>Vegetative</th>
<th>Reproductive</th>
<th>Senesced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter digestibility (%)</td>
<td>81</td>
<td>76</td>
<td>63</td>
</tr>
<tr>
<td>Metabolisable energy (MJ/kg dry matter)</td>
<td>11.7</td>
<td>10.9</td>
<td>8.7</td>
</tr>
<tr>
<td>Crude protein (%)</td>
<td>28</td>
<td>17</td>
<td>13</td>
</tr>
<tr>
<td>Neutral detergent fibre (%)</td>
<td>22</td>
<td>25</td>
<td>45</td>
</tr>
<tr>
<td>Acid detergent fibre (%)</td>
<td>15</td>
<td>16</td>
<td>30</td>
</tr>
</tbody>
</table>

Biserrula is a prolific seed producer
**Key messages**

- Biserrula should be managed as a grain crop when first sown on any paddock as the future productivity of the stand depends on seed yield in the year of establishment.
- Casbah is a public variety and can be freely bought and sold.
- Mauro® is protected under the Plant Breeders Right Act 1994 and the propagation of seed can only be carried out by agreement with licensees.

---

**Site preparation**

<table>
<thead>
<tr>
<th>Paddock selection</th>
<th>Avoid paddocks treated with sulfonylurea (SU) herbicides in the previous year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Avoid deep infertile sands or soils subject to waterlogging (see soil adaptation)</td>
</tr>
</tbody>
</table>

| Weed control       | Spray-top in previous spring or choose paddock where broad-leaved weeds were controlled well in a cereal or canola crop |
|--------------------| Best establishment is achieved if weeds can be controlled prior to sowing with a knockdown herbicide. This applies particularly to broad-leaved weeds such as doublegees |
|                    | Apply knockdown prior to establishment |
|                    | There are no chemicals registered to control broad-leaved weeds in biserrula. If livestock is available, use heavy stocking rates for short periods |

---

‘Biserrula] is easy and cheap to establish and is persistent, all it requires is to keep weeds under control so that it can establish properly in that first year’.
# Management of biserrula

## Establishment

| Inoculation | Essential with ‘Biserrula Special’ rhizobium  
Biserrula cannot use background rhizobia from other legumes |
|---|---|
| | Seeds coated with peat-based inoculant and lime pelleted  
Or, dry and peat-based granules mixed with seed and drilled at sowing |
| | Re-inoculate if a new strain of biserrula rhizobium is produced |
| Sowing time | Autumn to early winter  
Low rainfall areas: at the break of season (if weed control started in previous year)  
High rainfall areas: if required delay sowing to achieve good weed control with a knockdown herbicide |
| rate | 5 kg/ha is adequate in most cases but can vary between 2–10 kg/ha (lower rates when used in mixtures) |
| depth | Shallow sowing is critical, preferably < 2 cm |
| method | Preferably drilled. Seed can be top-dressed on the soil surface and covered with trailing harrows |
| Fertilisation | Phosphorus and potassium are the most important; apply according to soil tests |

## Insect control

<table>
<thead>
<tr>
<th>Insect</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aphids</td>
<td>Control is essential, especially for seed production</td>
</tr>
<tr>
<td>Red-legged earth mite</td>
<td>Control is essential prior to sowing until 3-leaf stage</td>
</tr>
<tr>
<td>Lucerne flea</td>
<td>Biserrula tolerates moderate infestation</td>
</tr>
<tr>
<td>Budworm</td>
<td>Biserrula tolerates moderate infestation</td>
</tr>
</tbody>
</table>

## Weed control

| Grazing | Grazing biserrula is an excellent non-chemical option for weed control, including herbicide-resistant weeds |
| Chemical | No herbicides are registered for use in biserrula pastures  
Avoid spray-topping in the establishment year as it can decrease seed yield by up to 85 per cent  
Weed-wiping combined with grazing can control ryegrass and wild radish effectively |

Biserrula-dominant pasture
Management of biserrula

**Grazing**

| Establishment year | Low stocking rate allows maximum seed set  
|                    | Sheep should be removed at flowering and not replaced until after pod maturity  
|                    | Approximately 45 per cent of seed survive ingestion by sheep (more in cattle)  
|                    | Seed is spread in manure  

| Established stands | Biserrula tolerates significant grazing pressure  
|                    | Winter grazing promotes prostrate growth  
|                    | Moderate grazing after flowering will allow seed set  
|                    | Summer grazing has little impact on future plant density and long-term persistence  

**Companion species**

| Casbah and Mauro® | Both cultivars grow well in mixtures with subclover, serradella, gland clover, rose clover and perennial and annual grasses  

**Farming systems**

| Casbah | Suited to intensive crop/pasture rotations  
|        | Should be cropped the season after establishment year  
|        | Can persist through a multiple crop phase  

| Mauro® | Suited to longer pasture phases  
|        | Can persist as a permanent pasture  

**Seed harvesting**

| Machinery | Biserrula can be harvested with a grain harvester but major modification to the drum is required  
|           | Seed can also be successfully harvested with specialist suction harvesting equipment  

![Biserrula seed in sheep pellet](image1.png)

![Harvesting biserrula seed](image2.png)

![Biserrula mixed with barley](image3.png)

Growing biserrula to improve grain and livestock production
Management of biserrula

Rules of thumb
- Avoid paddocks that are:
  - waterlogged
  - saline
  - deep infertile sands
  - frost prone
  - treated with SU herbicides in the previous season.
- Control weeds prior to biserrula establishment.
- Manage biserrula like a crop in the establishment year:
  - inoculate
  - fertilise
  - control weeds
  - control insects.
- Graze heavily in summer.
- Crop the paddock the year after biserrula is established.
- Control aphids to ensure good seed production.
- Reduce risk of photosensitisation in stock by:
  - grazing rotationally
  - monitoring stock while biserrula is flowering.

Main uses
- Farmers grow biserrula in Western Australia to:
  - Make crop production more sustainable and profitable
  - produce nitrogen
  - control herbicide-resistant weeds like rye grass and radish
  - replace lupins and subclover in intensive cropping systems
  - Increase livestock production
  - fill feed gaps in summer–autumn
  - extend length of growing season
  - produce prime lambs.
Key messages

- Biserrula pastures extend the period of green feed at both ends of the annual growing season and provide quality feed for livestock.
- Photosensitisation in livestock grazing biserrula can be managed by monitoring through flowering and removing stock from pasture if early symptoms occur.

Extended period of green feed availability

Biserrula is a valuable alternative pasture legume, especially for farming systems with livestock, as it can potentially extend the period of available green feed at both ends of the growing season. This relative advantage over other annual pastures is explained by seed and seedling attributes at the beginning of the growing season and by root depth at the end.

Well-managed stands of biserrula produce large amounts of seed which are stored in the soil seedbank. Biserrula’s seasonal and annual patterns of seed softening are such that a proportion of the seed is permeable to water and ready to germinate in autumn. Seeds germinate rapidly on the opening rains and established seedlings have a stronger capacity to survive false breaks than subclover seedlings.

At the end of the growing season, biserrula’s deep roots (up to 2 m in length) can access water from the soil below the root zone of annuals with shallower roots and produce green feed for up to four more weeks compared with subclover.

These plant traits make biserrula a good source of forage that farmers can use tactically to fill feed gaps at the end of the growing season, before crop stubbles become available, and early in the following season.

‘The bulk [of biserrula] that we have left on the paddock in summer is like a hay crop’.16
Increased livestock production
Table 1 shows that biserrula pastures provide more nutrients than cereal stubbles, which can potentially increase livestock production.

Table 1 Comparison of feed quality of two pastures with different biserrula content and three fodder crops’ straw

<table>
<thead>
<tr>
<th>Feed source</th>
<th>Crude protein (%)</th>
<th>Dry matter digestibility (%)</th>
<th>Metabolisable energy (MJ/kg DM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75 % biserrula&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15.5</td>
<td>63.4</td>
<td>9.3</td>
</tr>
<tr>
<td>62 % biserrula&lt;sup&gt;b&lt;/sup&gt;</td>
<td>15.3</td>
<td>57.7</td>
<td>8.3</td>
</tr>
<tr>
<td>Straw&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>4.3</td>
<td>49.7</td>
<td>6.9</td>
</tr>
<tr>
<td>Barley</td>
<td>6.1</td>
<td>52.9</td>
<td>7.5</td>
</tr>
<tr>
<td>Oat</td>
<td>6.9</td>
<td>55.9</td>
<td>8.0</td>
</tr>
</tbody>
</table>

Table 2 shows weight gains recorded in sheep weaners grazing biserrula pastures. Over the 51-day period the animals gained on average 6.5 kg/head, which is equivalent to 128 g/head/day.<sup>6</sup> This rate is 60 per cent higher than the average (80 g/head/day) estimated for sheep weaners grazing on a traditional diet of wheat stubbles from January to April (1990–1994) in six farms of the eastern wheatbelt.<sup>7</sup>

Table 2 Weight and condition score of sheep grazing biserrula

<table>
<thead>
<tr>
<th>Date measured</th>
<th>Mean liveweight (kg)</th>
<th>Mean condition score</th>
</tr>
</thead>
<tbody>
<tr>
<td>29/10/07</td>
<td>35.5</td>
<td>2.6</td>
</tr>
<tr>
<td>08/11/07</td>
<td>37.5</td>
<td>2.9</td>
</tr>
<tr>
<td>23/11/07</td>
<td>38.7</td>
<td>3.1</td>
</tr>
<tr>
<td>18/12/07</td>
<td>42.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Source: <sup>6</sup> 29 Oct. 2007; <sup>b</sup> 8 Nov. 2007; <sup>c</sup> After harvest 2006
**Farmers’ observed benefits from biserrula pastures**

<table>
<thead>
<tr>
<th>Benefits from biserrula</th>
<th>Farmers’ observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>High nutritional value</td>
<td>‘We had some feed tests done on the biserrula and the protein levels were 17 per cent’</td>
</tr>
<tr>
<td></td>
<td>‘Our stocking rates have increased due to the pasture feed being a lot better quality’</td>
</tr>
<tr>
<td>Increased stocking rate</td>
<td>‘I have been able to carry more sheep on the low performing paddocks where the biserrula is growing’</td>
</tr>
<tr>
<td></td>
<td>‘When the spring flush comes we need to triple the stocking rate there is that much feed available’</td>
</tr>
<tr>
<td></td>
<td>‘I have been able to double my flock due to better pasture management’</td>
</tr>
<tr>
<td>Extended green feed availability</td>
<td>‘[Biserrula can] also be grazed earlier than other legumes in autumn which is a huge bonus’</td>
</tr>
<tr>
<td></td>
<td>‘It also helps that the feed stays greener for longer at the end of the season’</td>
</tr>
<tr>
<td>Increased fertility</td>
<td>‘Ewe fertility has improved, they seem to be healthier overall’</td>
</tr>
<tr>
<td>Improved wool quality</td>
<td>‘Wool micron has also come back a bit which I was surprised about’</td>
</tr>
<tr>
<td>Improved pasture performance in dry years</td>
<td>‘Biserrula does better than subclover in the dry years. It managed to establish well when nothing else did. It would have been a disaster if we didn’t have the biserrula. It has helped me to maintain my flock size as it provides good quality dry feed’</td>
</tr>
</tbody>
</table>

**Farmers’ tips to manage stock on biserrula**

<table>
<thead>
<tr>
<th></th>
<th>Farmers’ observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graze rotationally</td>
<td>‘Put two biserrula paddocks next door to each other and rotate [stock]’</td>
</tr>
<tr>
<td></td>
<td>‘Try to continuously graze biserrula by rotating mobs. This helps with weed control and doesn’t let the biserrula get away too much’</td>
</tr>
<tr>
<td>Start grazing early</td>
<td>‘If grazing biserrula keep it low from the beginning’</td>
</tr>
<tr>
<td>Remove stock at flowering</td>
<td>‘At flowering and seed set remove stock to allow for more bulk for summer grazing as well as seed production’</td>
</tr>
<tr>
<td>Increase stocking rate before senescence</td>
<td>‘When it starts to ‘go off’ load it up with sheep to get good use of the green feed’</td>
</tr>
</tbody>
</table>
Livestock photosensitisation in biserrula

Sporadic photosensitisation of sheep occurs in association with the grazing of a range of plant species, including various grasses, cereals and legumes, but the incidence is generally very low. Over the last 10 years, isolated cases of photosensitisation have occurred in sheep grazing both Casbah and Mauro\textsuperscript{b} biserrula throughout the wheatbelt.\textsuperscript{12}

Photosensitivity is a state of heightened sensitivity to sunlight caused by the presence of photodynamic chemicals in the skin, cornea and mucous membranes. Photosensitivity may result in photosensitisation, which is the dermatitis and conjunctivitis produced in a sensitised animal after exposure to sunlight. The main types of photosensitisation are:

- primary, resulting when animals ingest particular plant compounds that are photodynamic and
- secondary, resulting when toxins in plants cause liver damage, which in turn results in the accumulation of the photodynamic compound phylloerythrin—a breakdown product of chlorophyll—in the blood.\textsuperscript{12}

There is currently no evidence that liver damage occurs in sheep grazing biserrula pastures.

Therefore, the assumption is that biserrula contains photodynamic chemicals that will cause a primary photosensitisation when consumed in sufficient quantity. Photosensitisation in sheep grazing biserrula has only occurred when the plant has made up greater than 40 per cent of the pasture on offer. There is also some evidence indicating that lambs may be more susceptible to developing photosensitisation.\textsuperscript{12}

It appears that biserrula pastures may only transiently contain high concentrations of the photodynamic compounds. Outbreaks of photosensitivity have occurred in late winter or early spring, when the green plant is growing rapidly and is about to flower. There is no evidence of photosensitivity having occurred when the dead plant is grazed in summer.\textsuperscript{12}

**Clinical symptoms**

Photosensitivity can develop within a few days of sheep moving on to biserrula pastures though it may develop over several weeks.

- The first indication that animals may be photosensitised are:
- restlessness
- head shaking
- rubbing and
- seeking out of shade.

Early signs of photosensitisation include swelling of ears, eyelids, mulesed area (tail), backline and muzzle. These are all the most exposed parts of the body. If allowed to progress these areas will become reddened, inflamed, and the overlying skin will die and peel off, exposing raw tissue underneath. In severe cases lambs may lose the tips or all of their ears, a general break in the wool can occur and sheep may appear lame.\textsuperscript{12}
Biserrula’s contribution to livestock production

Exposure raw tissue on the muzzle due to photosensitisation

Prevention and management

Farmers should adopt a cautious approach (regular monitoring) to the management of sheep grazing biserrula-dominant pastures. If photosensitisation is identified early and the animals are immediately removed from the pasture to shady areas (or under shelter if convenient) then the animals will normally recover well. Deaths due to biserrula photosensitisation are very rare.

The following practices will help to reduce the risk of photosensitivity developing when sheep are grazing biserrula pastures:

- Rotateally graze biserrula for short periods, especially during the high risk period of late winter and early spring.
- Provide alternative grazing, preferably of grass-based pastures or standing oat crop rather than other legume dominant pastures.
- Feed the sheep hay while they graze biserrula.
- In particular, do not graze lambs or recently shorn sheep on biserrula for periods greater than two weeks.12

Golden rule:

Monitor sheep grazing biserrula-dominant pastures all through flowering
Growers that have experienced incidents of photosensitivity in their livestock have learnt to live with the problem and find it easy to manage.

**Farmers’ tips to manage photosensitisation**

<table>
<thead>
<tr>
<th>Remove stock from biserrula if early signs occur</th>
<th>‘If you see photosensitivity put them on volunteer pastures ...’</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>‘We have a standing out crop or volunteer pasture paddock for [stock] to go to’</td>
</tr>
<tr>
<td></td>
<td>‘Our laneway works really well, it takes out the hassle associated with moving stock’</td>
</tr>
<tr>
<td>Graze rotationally</td>
<td>Photosensitivity is easy to manage with rotational grazing. Stock is rotationally grazed, two weeks in and two out early in the season, and later five weeks in and seven out</td>
</tr>
<tr>
<td>Avoid grazing at flowering</td>
<td>‘At flowering stock is removed and put back in after pods have formed’</td>
</tr>
<tr>
<td>Keep biserrula low from the start</td>
<td>‘The key to avoiding photosensitisation is grazing and keeping the biserrula low from the beginning, if it gets away from the sheep then that’s when it is seen’</td>
</tr>
<tr>
<td></td>
<td>‘Sometimes it occurs, others it won’t. We once put killers on a biserrula paddock and they didn’t get it, probably because there were enough weeds in it’</td>
</tr>
<tr>
<td></td>
<td>‘We put 5400 sheep on 130 ha of biserrula and they battled to keep up with it, they did extremely well on the pasture for three weeks and then began to show signs of photosensitisation’</td>
</tr>
<tr>
<td>Avoid lambing on biserrula</td>
<td>‘The worst case of photosensitisation was when we lambed in a biserrula paddock. The lambs were affected a lot. The ewes didn’t seem affected at all. It was in a 70 per cent biserrula paddock, and they were in there 70 per cent of the time as well’</td>
</tr>
</tbody>
</table>
Biserrula’s benefits to crop production

Key messages
- Biserrula is a legume and fixes atmospheric nitrogen, which becomes available for grain production over several seasons as it is released gradually.
- The combination of a biserrula pasture and grazing is an effective non-chemical approach to reduce weed populations in cropping areas, including herbicide-resistant weeds.
- This strategy does not work in other pastures species. Its success relies on the low animal preference for biserrula and on grazing starting before weeds initiate branch or tiller production.
- Research shows that biserrula is more sensitive than other annual pasture legumes to most chemicals.

‘To an extent we are growing our own nitrogen, we haven’t decreased the amount of fertiliser we are buying but we are getting much better yields. The production of nitrogen has been a bonus. We have looked at past soil tests with recent ones and soil nitrates have gone up. We are beginning to slowly reduce nitrogen inputs and beginning to play around with trace elements’.

Organic nitrogen supply
The amount of nitrogen produced depends on the amount of pasture grown, the more biserrula the more nitrogen. The amount of dry matter produced is determined by climate, soil and management-related factors. Therefore, to ensure high productivity it is essential to apply the pasture and livestock guidelines described in the first two sections of this bulletin.

Grazed biserrula pastures produce more nitrogen than those ungrazed. This is because appropriate grazing practices promote pasture growth. In addition, mixed biserrula pastures eventually become biserrula-dominant as a result of selective grazing, which will be discussed further under weed management.

‘We have got to start growing our own nitrogen with the recent fertiliser prices. For this the palatability [of biserrula] or lack of it helps. We decided to grow biserrula for the nitrogen benefits before the fertiliser price hikes. Three years ago we grew a canola crop on 30 kg of Agstar per hectare and nothing else. Hence we decided that it was a cheap option to use the biserrula before canola and afterwards to replenish the soil’.
Nitrogen produced by biserrula

As a rule about three per cent of the biserrula’s dry matter is nitrogen. Therefore, the amount of nitrogen produced by well nodulated biserrula can be calculated as follows:

\[
\text{kg biserrula N/ha} = \frac{\text{Total pasture dry matter (ton/ha)*} \times \% \text{ biserrula in pasture} \times 3}{10}
\]

*Including sheep pasture intake (ton/ha)

For example, if a 6 tonne per hectare pasture with 66 per cent biserrula is grown in a season, the biserrula component will have produced about 120 kg of nitrogen per hectare.

Crops growing in rotation with biserrula will benefit from this nitrogen in terms of the quantity and quality of grain they produce. However, not all of the nitrogen produced in a season becomes available to the following crop. How soon this occurs depends on the rate of nitrogen mineralisation, that is, how quickly organic nitrogen is changed into nitrate and ammonium, the forms that plants can utilise. The process is regulated mostly by microbial activity and by soil fertility, moisture and temperature.\(^1\)

Barley after biserrula without additional nitrogen fertiliser
Nitrogen available to crops
Table 3 shows the proportion of the nitrogen produced by a legume pasture that is released over several seasons. It is clear that this percentage varies depending on the length of the pasture phase. These estimates can be higher if summer rain occurs or lower after a short or dry season.

Table 3 Nitrogen from a 1, 2 or 3-year legume pasture phase available for crops over 5 years

<table>
<thead>
<tr>
<th>Pasture phase</th>
<th>Available nitrogen (as % or unit of N grown in one year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crop 1</td>
</tr>
<tr>
<td>1-year</td>
<td>40</td>
</tr>
<tr>
<td>2-year</td>
<td>60</td>
</tr>
<tr>
<td>3-year</td>
<td>70</td>
</tr>
</tbody>
</table>

Source

For example, if a biserrula pasture produces 120 kg of nitrogen per hectare a year, then using Table 3 the amount of nitrogen available for the following crop from a 1, 2 or 3-year pasture phase is:

<table>
<thead>
<tr>
<th>Pasture phase</th>
<th>Calculation from Table 3</th>
<th>Available N units/ha</th>
<th>Urea kg/ha</th>
<th>Cost* S/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-year</td>
<td>120 (40/100)</td>
<td>48</td>
<td>104</td>
<td>52</td>
</tr>
<tr>
<td>2-year</td>
<td>120 (60/100)</td>
<td>72</td>
<td>156</td>
<td>78</td>
</tr>
<tr>
<td>3-year</td>
<td>120 (70/100)</td>
<td>84</td>
<td>183</td>
<td>91</td>
</tr>
</tbody>
</table>

*When urea is $500/ton

The example shows that the supply of biserrula nitrogen to the rotation can be quite significant. This can potentially amount to considerable savings in nitrogen fertiliser.

‘The money that I am saving on nitrogen I am using on potash for my pastures and on lime for my crops, which overall is making the farming system more viable’.
Biserrula’s benefits to crop production

Table 4 Estimated nitrogen supply (kg/ha) from a pasture with different legume composition

<table>
<thead>
<tr>
<th>Legume composition (%)</th>
<th>3000</th>
<th>4000</th>
<th>5000</th>
<th>6000</th>
<th>7000</th>
<th>8000</th>
<th>9000</th>
<th>10 000</th>
<th>11 000</th>
<th>12 000</th>
</tr>
</thead>
<tbody>
<tr>
<td>All grass</td>
<td>0</td>
<td>14</td>
<td>19</td>
<td>23</td>
<td>28</td>
<td>33</td>
<td>37</td>
<td>42</td>
<td>47</td>
<td>51</td>
</tr>
<tr>
<td>Low</td>
<td>25</td>
<td>18</td>
<td>24</td>
<td>30</td>
<td>36</td>
<td>42</td>
<td>48</td>
<td>54</td>
<td>60</td>
<td>66</td>
</tr>
<tr>
<td>Median</td>
<td>50</td>
<td>22</td>
<td>29</td>
<td>37</td>
<td>44</td>
<td>51</td>
<td>59</td>
<td>66</td>
<td>73</td>
<td>81</td>
</tr>
<tr>
<td>High</td>
<td>75</td>
<td>26</td>
<td>35</td>
<td>43</td>
<td>52</td>
<td>61</td>
<td>69</td>
<td>78</td>
<td>87</td>
<td>95</td>
</tr>
<tr>
<td>All legume</td>
<td>100</td>
<td>30</td>
<td>40</td>
<td>50</td>
<td>60</td>
<td>70</td>
<td>80</td>
<td>90</td>
<td>100</td>
<td>110</td>
</tr>
</tbody>
</table>

Source 5

Table 4 shows the estimated nitrogen supply from a mixed pasture with different proportions of legume and grass. In a biserrula/wheat rotation, a good biserrula pasture of 6 tonne of dry matter per hectare, with median-high percentage of legume, supplies about 50 kg of nitrogen per hectare. Then, if a similar amount of nitrogen is provided from the long-term nitrogen pool, a total of 100 units of nitrogen is available for the next crop.

**Nitrogen required by crops**

The amount of nitrogen required to produce a crop with a certain amount of grain protein can be calculated by applying the following:

- There is 65 per cent efficiency of getting nitrogen into the crop and 75 per cent efficiency of getting that nitrogen to the grain. This means that there is nearly 50 per cent (65*75/100) efficiency of getting soil mineral nitrogen into the grain.

For example, one tonne of wheat with 12 per cent protein contains about 20 kg (12*10/6.25) of nitrogen. To get this amount of nitrogen in the grain there needs to be 40 kg of plant available nitrogen in the soil. If the goal is to produce two tonnes of wheat with the same protein content the crop will require 80 kg of nitrogen per hectare in the soil.

Therefore, the nitrogen available from the pasture and the soil pool should be deducted from the nitrogen required by the crop to decide if and how much nitrogen needs to be added.
Reduced weed burdens

Grazing

The combination of a biserrula pasture and grazing is a proven non-chemical solution to manage problem weeds in cropping areas, including herbicide-resistant weeds like ryegrass and radish. Grazing depletes weed burdens and prevents weed seed-set as animals often prefer weeds over biserrula. This selective behaviour does not occur to the same extent or at all in other annual legume pastures and is most likely due to differences in palatability among species. Although palatability is a qualitative measure of the overall acceptance and relish with which an animal consumes any given feedstuff, it is often related to the physical and chemical characteristics of the food.9

Table 5 shows relative preferences of sheep for different pasture species at three stages of their life cycle. An index of 50 means neutral preference, the higher the index above neutral the greater the preference and the lower the index the lower the preference.29 The results highlight that sheep preference for most species decreases as plants mature and also that sheep prefer ryegrass over biserrula.

Table 5 Relative preferences of several pasture species at three developmental stages offered to Merino sheep

<table>
<thead>
<tr>
<th>Species</th>
<th>Cultivar</th>
<th>Index of relative preference*</th>
<th>Vegetative</th>
<th>Reproductive</th>
<th>Senesced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biserrula</td>
<td>Casbah</td>
<td>3</td>
<td>40</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Burr medic</td>
<td>Santiago</td>
<td>80</td>
<td>62</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Ryegrass</td>
<td>Wimmera</td>
<td>93</td>
<td>20</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>French serradella</td>
<td>Cadiz</td>
<td>43</td>
<td>33</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Subclover</td>
<td>Dalkeith</td>
<td>58</td>
<td>8</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dinninup</td>
<td>50</td>
<td>25</td>
<td>69</td>
<td></td>
</tr>
</tbody>
</table>

Source 29, *alpha index x 1000

Preferential grazing controls weeds effectively without herbicides
Table 6 Weed control in a grazed and ungrazed biserrula-dominant pasture (2003) in a rotation with wheat (2002) and biserrula (2001)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Biserrula</th>
<th>Radish</th>
<th>Capeweed</th>
<th>Paterson's curse</th>
<th>Grasses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-trial</td>
<td>87.8</td>
<td>6.8</td>
<td>2.8</td>
<td>0.7</td>
<td>1.2</td>
</tr>
<tr>
<td>Grazed</td>
<td>99.6</td>
<td>0.1</td>
<td>0.2</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>Ungrazed</td>
<td>73.1</td>
<td>22.5</td>
<td>2.0</td>
<td>2.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Source 24

Table 6 shows the effect of grazing on the amount and composition of weeds in a biserrula/wheat rotation. In 2001, 12 per cent of the pasture dry matter was weeds. After two years weeds declined to almost zero in the grazed pasture and more than doubled without grazing. Radish was the most abundant weed in 2001 with almost 60 per cent of the weed dry matter, which at the end of 2003 was over 80 per cent in the ungrazed plots and zero in those that were grazed (Table 6).

Farmers control broad-leaved weeds with biserrula

“[Biserrula] helps control radish as the sheep eat the pods and leave the biserrula. It is really useful as it provides non-chemical control for radish as well as other weeds”.27

“Radish is controlled by our stock and I am happy with the way they control it. It means I don’t have to spray for radish”.6

“It is hard to remove the broad-leaved weeds without grazing the pastures. With the weeds it is better to control them early. We would suggest to continuously graze it but in rotating mobs. By doing this broad-leaved weeds, such as turnip and radish, are controlled by the sheep alone in most years”.16

“I control the weeds with the stock, and am happy with the way that it competes with the weeds. By growing the biserrula there has been a change in pasture composition, with the biserrula being the dominant component of the pasture. However this does vary from year to year, but with the sheep the weeds have been controlled and they seem to eat the capeweed down to the roots, I reckon they clean up 95 per cent of the weeds”.18
Table 7 compares results of the effect of grazing during late winter and early spring on weed burdens in newly sown swards of three different annual pasture legumes.

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Casbah biserrula</th>
<th>Sava snail medic</th>
<th>Santiago burr medic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total dry matter (kg/ha)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before grazing: 23 Aug.</td>
<td>853</td>
<td>1009</td>
<td>935</td>
</tr>
<tr>
<td>After grazing: 13 Sep.</td>
<td>1026</td>
<td>1337</td>
<td>1274</td>
</tr>
<tr>
<td>2 Oct.</td>
<td>1075</td>
<td>1528</td>
<td>960</td>
</tr>
<tr>
<td>16 Oct.</td>
<td>990</td>
<td>1169</td>
<td>376</td>
</tr>
<tr>
<td>Pasture composition (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legume</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before grazing: 23 Aug.</td>
<td>56</td>
<td>68</td>
<td>78</td>
</tr>
<tr>
<td>After grazing: 13 Sep.</td>
<td>83</td>
<td>81</td>
<td>78</td>
</tr>
<tr>
<td>2 Oct.</td>
<td>94</td>
<td>84</td>
<td>88</td>
</tr>
<tr>
<td>16 Oct.</td>
<td>94</td>
<td>84</td>
<td>73</td>
</tr>
<tr>
<td>Weeds including ryegrass</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before grazing: 23 Aug.</td>
<td>44</td>
<td>32</td>
<td>22</td>
</tr>
<tr>
<td>After grazing: 13 Sep.</td>
<td>17</td>
<td>19</td>
<td>22</td>
</tr>
<tr>
<td>2 Oct.</td>
<td>6</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>16 Oct.</td>
<td>6</td>
<td>16</td>
<td>27</td>
</tr>
<tr>
<td>Ryegrass only</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before grazing: 23 Aug.</td>
<td>17</td>
<td>20</td>
<td>11</td>
</tr>
<tr>
<td>After grazing: 16 Oct.</td>
<td>3</td>
<td>12</td>
<td>15</td>
</tr>
</tbody>
</table>

Weed dry matter initially present decreased almost 90 per cent in the biserrula pasture and 50 per cent in the snail medic, but increased in almost 20 per cent in the burr medic. Note also in Table 7 that the initial proportion of ryegrass dry matter in the pasture declined over 80 per cent in the biserrula and 40 per cent in the snail medic, but increased almost 40 per cent in the burr medic. These results highlight that grazing biserrula reduces weed burdens more so than in other annual legumes.

A closer look at the impact of combining grazing and pasture species for the control of ryegrass is shown in Table 8. The density of ryegrass tillers in the grazed biserrula pasture declined about 80 per cent in comparison with the ungrazed biserrula and this contrasts with twice as many tillers in the snail medic and almost no change in the burr medic. These results indicate that animals selected ryegrass over biserrula during the vegetative phase, which is consistent with the preference indices in Table 5. In addition, the shorter seed head of ryegrass in the three different species suggests that the livestock grazed ryegrass more heavily during the reproductive phase (Table 8).
Biserrula’s benefits to crop production

Table 8 Effectiveness of grazing and pasture legume species in depleting the fitness of a ryegrass population

<table>
<thead>
<tr>
<th>Ryegrass traits</th>
<th>Casbah biserrula</th>
<th>Sava snail medic</th>
<th>Santiago burr medic</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. tillers/m²</td>
<td>85</td>
<td>93</td>
<td>145</td>
</tr>
<tr>
<td>Ungrazed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grazed</td>
<td>16</td>
<td>171</td>
<td>139</td>
</tr>
<tr>
<td>Seed head length, cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ungrazed</td>
<td>13</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>Grazed</td>
<td>5</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>No. seeds/m² *</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ungrazed</td>
<td>4240</td>
<td>5352</td>
<td>7504</td>
</tr>
<tr>
<td>Grazed</td>
<td>311</td>
<td>6522</td>
<td>5396</td>
</tr>
</tbody>
</table>

Source: *, Estimated

The estimated numbers of ryegrass seeds (Table 8) suggest that there were almost 4000 seeds per square metre less in the biserrula grazed pasture, a 93 per cent decline when compared with the ungrazed biserrula and more when compared to the medic pastures with or without grazing. It appears from the combined results in Table 8 that the success in depleting weed seed production is strongly related to preventing the formation of seed heads, which can only be achieved if grazing begins before branch or tiller initiation. If this strategy is applied consistently, most populations of ryegrass can be reduced considerably after two consecutive years of pasture and those of brome grass after three years.

Farmers control grass weeds with biserrula

‘Ryegrass numbers are down. I have tried different rotations but need to stick to three years of non-cereal in order to do a better job of controlling the ryegrass, which is resistant to group B’s. We are controlling brome grass early with a grass selective and it is cheap but it leaves behind the ryegrass because it is resistant. I do come back and spraytop’. 9

‘Pasture composition has changed. The barley grass—which was a problem—has disappeared. The biserrula is also helping to control the resistant ryegrass, which is a huge plus’. 17

Biserrula pastures can be used successfully as part of an integrated weed management program and help reduce the use of herbicides in grain and livestock production industries. In some situations chemicals are still required to assist weed management.

Chemical control

Biserrula’s tolerance to herbicides

There are no herbicides specifically registered for use on biserrula. Therefore, for the purpose of scientific research, a selection of products registered for subclover, medic, serradellas, or pastures in general, were chosen to investigate herbicide tolerance in biserrula pastures.
Eleven trials were undertaken over a period of six years in different soils and environments of the wheatbelt. They indicated that there is wide variation among pasture legumes in their responses to different herbicides and that biserrula is more sensitive than other pasture species to most herbicides. Considerable damage is caused by Broadstrike®, Raptor®, Spinnaker®, MCPA amine, Diuron®, Simazine®, 2,4-D amine, Tigrex®, Jaguar®, Gramoxone® and Brodal®. Therefore, when planning to grow biserrula it is essential to control as many weeds as possible with a knockdown herbicide prior to sowing, rather than relying on post-emergent herbicides. On paddocks with high weed densities consider even delaying sowing for the sake of effective weed control and apply a double knockdown if the opportunity arises.

**Spray-topping**

Spray-topping is one strategy used in pastures for reducing seed-set of annual grasses. This involves the application of a non-selective herbicide followed by heavy grazing. The time of the application is critical and should be at flowering, when grasses are most sensitive and low rates of chemical are sufficient to sterilise the seeds.

Research results have shown that biserrula is very sensitive to Gramoxone® and glyphosate when used for spray-topping. This practice is not recommended in the year of establishment. Spray-topping may be an option for later years in the rotation if a good biserrula soil seed bank is present.

**Weed-wipers control tall weeds**

**Weed-wiping**

In the absence of livestock weed-wiping is often used to kill weeds in crops. A strip of material is attached to a horizontal frame to make the blanket wipers which are used to brush the chemical on the weed tops. This technique allows the application of herbicide directly on the target weeds. Weeds must be 20–30 cm taller than the pasture canopy to prevent damage as non-selective herbicides are generally used.

The best time of application is September to early October when weeds are flowering or at early stages of seed development when the seed is still soft. Ryegrass can be killed with glyphosate at one litre in 27 litres of water or paraquat at one litre in 19 litres of water. Glyphosate is more effective in radish than paraquat.
**Biserrula’s benefits to crop production**

**Tips for successful weed-wiping**

- Control herbicide flow to avoid dripping onto the crop.
- Stabilise broadacre weed-wipers with wheels to avoid contact with the crop’s canopy.
- Apply only where target weeds rise more than 25 cm above the crop canopy.
- For dense patches of weeds consider wiping in two directions.

‘Weed-wipers work well on the ryegrass in the biserrula’.16

‘[Weed-wiping] killed a bit of the biserrula but not a lot and the control that I got of the ryegrass was really good’.2

**Sustainable crop rotations**

Biserrula can contribute to sustain agricultural industries across the wheatbelt. From a pastures perspective, there are three keys to sustainable crop/pasture rotations:

- To match species and cultivar to soil and climate
- To select the most suitable cultivar for the type of farming system
- To implement correct agronomic practices for pasture establishment and management
Each topic has been addressed to a certain extent in this bulletin. At this point, it is important to mention some general guidelines in relation to the type of farming systems for which the two cultivars of biserrula were developed. Firstly, maintaining a large soil seed bank is essential to sustain productive pastures. For this reason, in the year biserrula is first grown the aim is to create a large soil seed bank that will persist through crop phases of different lengths.

Casbah was developed to suit the more intensive grain production systems typical of the lower rainfall areas. Hence, this short-season cultivar has a very high proportion of hard (impermeable) seeds of which only a small percentage becomes ready to germinate each year. On the other hand, Mauro® is softer seeded than Casbah and was developed to persist through longer pasture phases in grain and livestock production systems of higher rainfall areas. Now, independently of the cultivar and the length of the crop phase, in the case of Casbah it is safer to grow a crop in the year after biserrula is established and more so if pasture seed yield was low. In the case of Mauro®, a grain crop can be grown in the year after sowing but it is not essential.

In terms of crop species, any crop can be grown in rotation with biserrula. Biserrula can replace lupins in soils where this crop cannot grow as biserrula is adapted to a broader range of soil types. Biserrula also works well before a canola crop as it helps to reduce input costs.

**Benefits of biserrula in crop rotations**
- nitrogen fixation
- effective control of herbicide-resistant weeds
- effective control of grasses that host pathogens of cereal diseases
- break disease and insect cycles
- improved organic matter
- reduced water leakage and nutrient leaching compared with other annuals.
Biserrula’s benefits to crop production

Biserrula regenerating after canola

**From biserrula to crop**

Paddocks after a biserrula phase are expected to be weed-free but some of the biserrula will self-regenerate each year. This is not generally a problem as biserrula can be killed with most in-crop herbicides.

**Farmers experience biserrula in crop rotations**

‘The first year we sowed biserrula, it was a dry year. We had to put sheep on it earlier than what we wanted as other paddocks of ryegrass/subclover were bare. There wasn’t a lot of biserrula bulk but it still managed to set seed. I think that you can be a bit harder on it than what you can on a volunteer pasture. It even managed to come back after two years of crop, which I was very impressed about’.  

‘Subclover is dwindling away under the heavy cropping, whereas biserrula will come back after up to five-six years crop. It could even work as a green manure type crop, I might try this in the future’.

Growing biserrula to improve grain and livestock production
‘Our rotation is too short for subclover so we have gone with others such as biserrula’. Pastures are being improved mainly for cropping benefits such as rotation. It also works for us in the rotation on the paddocks that are not productive for intensive cropping. If we didn’t have sheep we would still grow it, we would just green manure it’.\textsuperscript{27}

‘With a pasture you want to be able to do up to 5 years crop and still have it come back, I have seen biserrula do this well, whereas the subclover has struggled. If I didn’t have sheep I would green manure it’.\textsuperscript{8}

‘There isn’t a problem when you go from a biserrula pasture back to crop as the herbicides that we use in wheat and barley kills it’.\textsuperscript{8}

‘In the crops it is working well, it is not an issue at all in the cropping phase as none germinate’. It must be the herbicide that is controlling it during the crop phase as it can’t be used on biserrula’.\textsuperscript{27}
Economics of farming systems with biserrula

The research results in previous sections show the ways in which biserrula can contribute to make grain and livestock production systems more productive and sustainable. How these changes impact on profitability is essential for farmers to consider adopting this practice. Therefore, this section briefly discusses the drivers of profitability in mixed farming systems and grain production systems with biserrula.

Modelling studies, assuming correct agronomic practices are implemented on an average rainfall year, have shown that biserrula can substantially improve the profitability of different farming systems.

Drivers of profitability in mixed farming systems with biserrula $^{13, 20, 23}$

- increased pasture growth rate in suitable soil types
- improved pasture quality
- increased stocking rates
- increased sheep turnoff
- increased area of cereals at the expense of pulses and oilseeds
- filling feed gaps with quality feed
- availability of green feed early and late in the season and lower costs of supplementary feeding.

Biserrula increases profitability of mixed farming systems

In mixed systems the studies highlighted the significance of the extended growth cycle of biserrula compared with subclover and annual grasses. This advantage allows livestock to sustain or increase further weight gains as they can access high quality green feed for several weeks longer. The availability of this additional feed at such time of the year is critical as it coincides with the period between the senescence of unimproved pastures and the availability of crop stubbles. $^{13, 20, 23}$

The impact of soil type on the profitability of biserrula is also significant. The increase in dry matter production as a result of higher pasture growth rates can increase profitability by $13-71$/ha in comparison with that on less suitable soils. The soils included in the model were: rocky red brown loamy sand/sandy loam, brownish grey granitic loamy sand, deep sandy surfaced valley, shallow sandy surface valley soil and loamy sand over clay. $^{23}$
Drivers of profitability in grain production systems with biserrula\textsuperscript{3, 13, 25}

- replacing lupins on paddocks with herbicide-resistant ryegrass
- replacing lupins where crop production is low due to pests and diseases
- replacing volunteer pasture in rotations with wheat
- replacing subclover in crop rotations of different intensity
- replacing lupins on paddocks with a mix of soil types
- substituting grain legumes to increase flexibility in management
- lower risk than in cropping rotations including grain legumes

In grain production systems biserrula is a type of insurance for the rotation. In the case of long-term wheat/lupin rotations with low yields and high costs of production due to herbicide-resistant ryegrass, a biserrula phase can be as profitable as intensive cropping rotations.

A comparison between biserrula and volunteer pasture grown in rotation with wheat showed that self-regenerating biserrula pastures are more profitable because of the increase in wheat yield and quality. The analyses also showed that in the event that biserrula failed to persist, re-seeding it every pasture phase is viable if wheat yields are of the order of 2 ton/ha.\textsuperscript{3} A biserrula phase instead of lupins is also less risky, particularly on farms with a mix of soil types.\textsuperscript{26} Farmers growing biserrula suggest that lupins are a higher risk crop and that losses from a grain legume can be far greater than those from a biserrula pasture.

Understanding how biserrula functions and affects other components of the farming system is essential to realise its potential benefits. This involves following the guidelines for establishment and management of biserrula discussed in this bulletin. Farmers applying this technical knowledge will be able to reap biserrula’s benefits over the whole farm providing favourable environmental conditions occur.
Economics of farming systems with biserrula

‘You get better results from growing biserrula and remove the exposure of losses that lupins give, so gross margins and profit are better with biserrula than lupins’.¹⁴

‘Biserrula is a great replacement for lupins as it thrives year in year out whereas the lupins don’t grow well and when they do they are full of radish and ryegrass. Biserrula on the other hand is sown once and then it regenerates even in mongrel years’.²
‘Photosensitivity has nothing on lupinosis; biserrula defeats lupins all-round’

Levett

Key messages
- Photosensitivity is no harder to manage than lupinosis.
- Biserrula works better in the system than lupins as it decreases crop costs and is flexible, with high nitrogen benefits.
- Weed populations are decreasing along with the crop yields being significantly better on the biserrula paddocks.

Background
Cameron Levett and his father Max began growing biserrula in 2000 on Max’s property, at the time they had a lot of stock and were looking for a better feed source than volunteer pastures. It also had the benefit of providing an alternative for lupins. Cameron sees lupins as a total failure on medium-textured yellow soils with high costs and herbicide-resistant weeds. He now grows biserrula instead of lupins in his rotation and believes he has a simpler and more sustainable system.

Farm statistics
Location: Carnamah
Farm size: 6000 ha
Rainfall: 330 mm
Enterprise: crop 70 %, pasture 30 %
Stock: usually 6000 ewes and 4000 lambs
Area to biserrula: 4500 ha
Soil type: pH 6.5, red deep york gum soils

That first year
<table>
<thead>
<tr>
<th>Preparation</th>
<th>Roundup® @ 1 L/ha as a knockdown and the sheep get the rest of the weeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sowing rate</td>
<td>5 kg scarified seed per hectare and slurry inoculant</td>
</tr>
<tr>
<td>Technique</td>
<td>Air-seeder with knife points and no harrows, just dusted the ground 1–2 cm, not every point touched the ground but could see that it had definitely scratched the ground</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>None with the seed</td>
</tr>
<tr>
<td>Stock</td>
<td>Grazed as sowing, they leave the biserrula and eat the weeds out, especially radish</td>
</tr>
</tbody>
</table>
Farmers’ experiences with biserrula

Management

Grazing
Cameron is impressed with the way that biserrula handles the stock. In spring, sometimes he ends up with large quantities of biomass when the pasture grows rapidly and he cannot increase the stocking rate to match the feed on offer. ‘When the spring flush comes along, you need to triple your stocking rate’.14

Cameron does not rotate his stock on biserrula pastures as the extent to which photosensitivity occurs is smaller and its effects nothing compared to lupinosis. When he observed this problem, it was on a highly productive biserrula-dominant pasture where 60–80 sheep were affected out of 10 000. ‘If you see photosensitivity put them on cereal stubble ... only a few sheep are affected and it is just like scabby mouth really, even grass seeds can be worse than photosensitivity’.14

Pest/disease
Cameron is happy with the way in which sheep control herbicide-resistant radish on biserrula paddocks. He controls aphids with a boom spray as he found that a mister was ineffective.

Benefits

Livestock
Cameron got lambing percentages of 110–130 per cent after ewes were grazing biserrula, which is the highest Cameron has seen, so he thinks that photosensitivity does not affect fertility.

Cameron has been able to increase stocking rates when the seasons are good. In dry years, he can sustain his stock better on biserrula pastures than on subclover volunteer pastures. Cameron suggests that reasons for this may be due to the higher protein content (17 per cent) of biserrula, which was seen after he had feed tests done.

Weed control
For Cameron the level of weed control that can be obtained by growing biserrula is the most beneficial characteristic, however, ‘sheep are needed to get the best out of the biserrula’.14

Herbicide-resistant radish is being controlled by stock as ‘it is the first thing that they eat and they leave the biserrula alone’.14 Biserrula gives the radish a break from herbicides which Cameron likes and he believes that it is easy to graze out of the biserrula. [Early in the season] ‘I had 500 sheep on a 600 ha paddock, they ate the radish and kept the paddock reasonably clean but when the spring flush came I needed to triple the stocking rate so that the biserrula growth was eaten’.14

Rotation
Cameron believes organic carbon and nitrogen would have been improved in paddocks with heavy stands of biserrula. ‘Biserrula would be able to stand with soil fertility alone without the weed benefits. It is also helping to decrease weed populations, which in turn improves crop yields significantly and decreases cropping costs’.14
Nitrogen

‘The whole package of biserrula is much underestimated for long-term use. It’s not just the weed control but it is also the nitrogen that is produced and the stock feed bulk. It is still worth growing biserrula for nitrogen with urea at $600/ton’.\textsuperscript{14} He believes that the nitrogen production of biserrula is greater than that of lupins due to biserrula’s larger biomass production. With the dry years he says that it is hard to tell how much nitrogen biserrula produces but it is noticeable several crops after biserrula. He estimates that there is enough nitrogen produced to meet the needs for a 2-ton wheat crop.

Difficulties

His biggest failure with biserrula was due to ineffective control of aphids in early spring, which resulted in very little seed set. ‘We used a mister instead of a boom spray, we definitely should have used the boom spray with a bigger water rate’.\textsuperscript{14}

Cameron sows the biserrula in dry conditions despite this practice carries considerable risk of failure. In dry years he has lost money sowing biserrula but believes he would have lost much more if it had been lupins (Table 9). Establishment costs in biserrula are lower than in lupins in part because he does not fertilise the biserrula.

Table 9 Comparing costs of establishment of biserrula and lupins in Carnamah WA

<table>
<thead>
<tr>
<th></th>
<th>Biserrula</th>
<th>Lupins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed</td>
<td>5 kg/ha @ $3/kg = $15/ha</td>
<td>Pickled seed 70 kg/ha @ $300/ton = $21/ha</td>
</tr>
<tr>
<td>Inputs</td>
<td>Inoculant = $20/ha</td>
<td>Herbicide = $12/ha</td>
</tr>
<tr>
<td>Area</td>
<td>Dry sown 3000 ha</td>
<td>If sown 3000 ha</td>
</tr>
<tr>
<td>Loss</td>
<td>$60 000</td>
<td>$99 000</td>
</tr>
</tbody>
</table>

Cameron would rather manage photosensitivity than lupinosis as he believes its effects are little compared with lupinosis or any other common livestock health issues such as scabby mouth.

Farming system

Cameron has substituted lupins with biserrula in wheat rotations. He says that the biserrula is excelling on red loamy valley soils where lupins fail, so it is giving him more options than the wheat/lupin rotation. Cameron also believes that he could make meadow hay from the biserrula on these soils as it really bulks up.

In a perfect world Cameron thinks that biserrula would suit a 60 per cent crop and 40 per cent biserrula rotation without any volunteer pasture as he believes that there is no need to worry about photosensitivity. He says that ‘the long-term gain of biserrula is better than a few photosensitivity issues, especially when lupins are harder to manage with lupinosis than biserrula with photosensitivity’.\textsuperscript{14}
Economics

Cameron firmly believes that biserrula will improve farm profits around his area. To estimate the contribution of biserrula to the system he considers ‘whatever nitrogen is worth and how much biserrula is produced and compares it to whatever it costs to get and apply urea for a couple of years’. Cameron has saved on costs of urea for two years on some of his crops growing in rotation with biserrula. He would usually apply 100 kg urea for a potential 2-ton wheat crop. After a biserrula phase, he is still getting the same yield without any urea application. ‘You get better results and remove the exposure of losses that lupins give, so gross margins and profit is better with biserrula than lupins’. Biserrula does well when wheat does well and will not perform in years when wheat doesn’t perform.'
‘Biserrula reducing money spent on stock feed’

Key messages
- Biserrula is cheap and easy to establish and is a great replacement for lupins.
- It needs to be treated like a wheat crop in the first year and then it will persist and regenerate well on its own. It will look after itself.
- Keep weeds under control with sheep or spray.

Background
Phil Bear and his wife Michelle began growing biserrula in 2001 at Moonjin, their property. Phil was initially planning to grow a serradella mixture but as Charano® was expensive he opted for biserrula, which was cheaper. Since then Phil has continued to grow biserrula as it has been so successful for him. It is easy to establish providing weeds are kept under control in that first year. Phil targets the lower performing paddocks and believes that they have turned around and he expects to be able to crop them again in the future.

Farm statistics
Location: Dowerin
Farm size: 3600 ha, 3000 ha arable
Rainfall: 300 mm
Enterprise: crop 50 %, pasture 50 %
Stock: 3500 sheep
Area to biserrula: 900 ha
Soil type: various

That first year
<table>
<thead>
<tr>
<th>Preparation</th>
<th>Knockdown before seeding and treat biserrula like a wheat crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sowing rate</td>
<td>5 kg/ha with Cadiz in first year and just biserrula in other years, inoculant</td>
</tr>
<tr>
<td>Technique</td>
<td>Burgo air-seeder and bar at 6 km/hr with Agmaster points and boots got rolling harrows which are lifted up. Knifes are in the ground but lifted up a bit from where they are for wheat.</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>Sometimes fertilise depending on prices, so not lately. Top-dress pastures</td>
</tr>
<tr>
<td>Stock</td>
<td>On and off at a fairly high stocking rate, move them out once they have been in there around 3–4 weeks</td>
</tr>
<tr>
<td>Pest control</td>
<td>Grass-selective herbicide during the year, used the weed-wiper</td>
</tr>
</tbody>
</table>
**Management**

*Grazing*

Phil stocks his biserrula paddocks at a fairly high rate and uses a rotational system. Sheep are removed from the pasture after three to four weeks. One year when he had lambs and ewes on a biserrula paddock he observed photosensitivity. The lambs were affected but the ewes did not appear to be affected at all. ‘It isn’t that much of an issue’.

*Pest/disease*

‘I do a knockdown at the start of the year, either before it germinates or is sown’. Phil chooses not to spray-top so that the biserrula can set seed and keep growing later into the season.

‘Radish is controlled by our stock and I am happy with the way they control it, it means I don’t have to spray for radish’. Weed-wiping works very well for ryegrass control, it killed a bit of the biserrula but not a lot and the ryegrass control I got was good.

Phil looks for aphids around spring time as they require control. ‘When there is a bit of a dry spell it starts to shrivel, you need to have a good look and see if it is aphids or the dry spell’. In 2008 the biserrula was affected by aphids but after spraying it rained and the biserrula recovered and damage from the aphids was not noticeable.

**Benefits**

Phil’s biserrula paddocks are doing better than those with subclover, which he says are struggling. ‘If we get summer rains the clover comes up quickly but then dies off, whereas the biserrula eventually comes up but holds on until the proper break comes’. Phil also mentioned that the biserrula does better in a dry year. ‘It managed to establish well in dry years when nothing else did, it would have been a disaster if we didn’t have the biserrula. It has helped me to maintain my flock size, as it provides good quality dry feed’.

Phil perceives biserrula as a replacement for lupins as when this does not grow well it is full of radish and ryegrass. ‘Biserrula is sown once and then it thrives year in year out. It establishes in mongrel years, so when we get a good year imagine how easy it will be’. Phil believes that lupins at $300/ton are easier and cheaper to buy.

Free nitrogen from biserrula is a bonus to Phil’s farm. ‘I am definitely decreasing nitrogen application on the biserrula paddocks, I put about 10 units of nitrogen down the tube and that’s it’. On the other paddocks where Phil is not growing biserrula he has to come back with another 25–30 units of nitrogen. ‘I grow biserrula for $20/ha, I can’t put out enough urea for $20/ha’.

Phil has found the biserrula to be versatile as he has been able to sow it early or late. I can do whatever with it and it works. ‘It also helps that feed stays green for longer’.
Difficulties
‘Just need to be mindful of aphids and keep an eye on stock to see if there is any photosensitivity’. He also mentioned that in the dry months biserrula does not hold the soil as well as subclover does, so it can cause soil erosion if the stock is left on it too long.

Sheep do a reasonable job in controlling the broad-leafed weeds. They do alright with the turnip until it turns woody, so Phil believes that this could be an issue.

Farming system
‘The second year always has to be a crop year. One year we got caught when we didn’t do this and there wasn’t much biserrula that came up. If you crop it the second year, then the third year it is thick as anything and you have that much seed there for other years’.

Economics
Phil can see the benefits of growing biserrula as his poor performing paddocks have improved and could carry more sheep and get better wheat yields in the long term. ‘It is a sustainability thing, if we get half of the farm in, it will make life easier’.

Interview by Natalie Hogg on 20th September 2009
Farmers’ experiences with biserrula

‘Biserrula helping the fight against resistant ryegrass and other weeds’
McDougall

Key messages
- Preferential grazing of the non-biserrula components of the pasture is allowing for weed control without the need for herbicides.
- Ryegrass numbers have gone from 1000 plants/m² to a paddock that we can now crop.
- Biserrula produces enough nitrogen to grow a canola crop on 30 kg of Agstar per hectare.

Farm statistics
Location: Tincurrin
Farm size: 5000 ha
Rainfall: 300 mm
Enterprise: Crop 70 %, Pasture 30 %
Stock: 6000 sheep plus lambs
Area to biserrula: 360 ha, rotated.
Soil type: medium to heavy country, duplex soils, sandy gravel and off white sands.

Background
John and Gordon McDougall from Acadia, a 5000 ha property near Tincurrin, began to grow biserrula in 2000. The initial reason for growing the biserrula was to try and manage the Select®-resistant ryegrass, which is found over the farm. They chose biserrula because of its lower palatability compared with weeds expecting sheep to graze them out of the pasture and leave a more dominant biserrula stand. ‘We had around 1000 plants/m² of ryegrass, which was what we wanted to address. We are controlling the resistant ryegrass by grazing biserrula’.16

That first year
| Preparation | Knockdown |
| Sowing rate | 4 kg/ha in early April |
| Technique | Air-seeder |
| Fertiliser | Double the amount of super that is put on crop (April) |
| Stock | Late in the season stock went on |
| Pest control | Grass-selective herbicide and insecticide for the aphids |
Management

Grazing
John and Gordon are happy with the feed biserrula provides early in the season. When other sources of feed become available they begin to graze rotationally with large mobs to keep the biserrula fresh and short.

They suggest:
- Keep biserrula low from the beginning to avoid photosensitivity
- Graze continuously with rotating mobs. Broad-leaved weeds such as turnip and radish can be controlled by the sheep alone in most years.
- The chances of photosensitisation are lower if the biserrula stand is weedy.
- Remove stock at flowering/seed set for higher seed production.
- Having a laneway helps with rotational grazing for larger mobs.

Livestock
'Stock numbers have not increased due to the dry years. However the bulk that we have left in the paddock in summer is like a hay crop. Biserrula is able to provide early feed. Towards the end of the season when it is flowering and setting seed we remove stock and this also allows for more bulk to be available for summer grazing'.

Weed control
'We had around 1000 plants/m² of ryegrass on the now biserrula paddocks. We establish biserrula then we go back to crop, we then grow three years of biserrula to really clean it up and then go one in one out, which helps control the ryegrass. Weed-wiping works well on the ryegrass in the biserrula, it is hard to remove the broad-leaved weeds (turnip and radish) if you don’t graze the biserrula. It is better to control weeds early and we graze continuously with rotating mobs, by doing this the broad-leaved weeds are controlled by the sheep alone in most years'.

Rotation
John and Gordon always crop the year after biserrula establishment and then they usually do two to three years biserrula then a crop. On the ryegrass-resistant paddocks they grow three years of biserrula to really clean it up and then go one in one out which they say ‘works well to control the ryegrass. ... we even found that after four years in crop the biserrula still comes back’.
**Nitrogen**

John and Gordon look at biserrula as growing their own nitrogen with the recent fertiliser prices. They decided to do this before the price hike when three years ago they were able to grow a canola crop on 30 kg of Agstar per hectare. ‘We decided that it was a cheap option to use the biserrula before canola and then afterwards to replenish the soil and felt that subclover wasn’t able to produce enough nitrogen in comparison to biserrula’.  

“We are controlling the resistant ryegrass by grazing biserrula”
‘Biserrula proves to be a winner for intensive cropping’

Stokes

Key messages
- During the dry years the biserrula set seed, whereas our subclover hasn’t set seed for four years.
- Biserrula is another tool to control weeds without having to use chemicals so we will have it for many years to come.
- To an extent we are growing our own nitrogen, we haven’t decreased our fertiliser inputs but we are getting better yields.

Background
Twelve years ago the Stokes family introduced biserrula onto their farm Mt Erin. It began with a small trial and was followed with a 40 ha paddock. Biserrula was introduced primarily for cropping benefits: weed control and rotation, as their cropping rotations were too intensive for subclover. Other benefits are now being realised with biserrula being an excellent substitute for subclover which has not set seed for four years due to the dry years.

Farm statistics
Location: Chapman Valley
Farm size: 3800 ha
Rainfall: 450 mm
Enterprise: crop 60 %, pasture 40 %
Stock: usually 5000 but due to the dry years 2000 sheep
Area to biserrula: 260 ha. This year 120 ha regenerating, 100 ha under crop and 40 ha being sown
Soil type: sandy loam

That first year

<table>
<thead>
<tr>
<th>Preparation</th>
<th>Weeds controlled with a knockdown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sowing rate</td>
<td>3–5 kg/ha</td>
</tr>
<tr>
<td>Technique</td>
<td>Air-seeder with knife points and rotary harrows</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>Nil</td>
</tr>
<tr>
<td>Stock</td>
<td>Let pasture grow a little and then grazed it to late winter</td>
</tr>
</tbody>
</table>
Management

Rotation
Pastures are being improved on Mt Erin, mainly for benefits in the cropping rotation. ‘Our rotation is too short for subclover so we have gone with biserrula’. Jason is finding that biserrula is working on the unproductive paddocks. Jason believes that if they didn’t have sheep they would still grow biserrula, they would just green manure it.

Grazing
Photosensitivity is easy to manage with rotational grazing:
- Biserrula can be grazed earlier than other legumes.
- Early in the season graze rotationally two weeks in two weeks out.
- During winter graze rotationally five weeks in seven weeks out.
- At flowering remove stock and put them back when pods have formed.
- Have a volunteer pasture or standing out crop for stock to move too.

Pest/disease
Jason says that aphids need to be controlled; otherwise seed set can be limited, which means less regeneration in following years. ‘The impact aphids have depends on when they attack’.

Benefits

Livestock
Biserrula has helped to improve pasture quality and as a result Jason is increasing stocking rates. Biserrula can be grazed earlier than other legumes in autumn which is seen as an enormous advantage by the Stokes family.

Weed control
Grazing pressure for radish control is achieved in smaller paddocks however in larger paddocks it is not that easy. Jason says ‘the sheep eat the radish pods and leave the biserrula’ and believes that it is really a useful non-chemical control for radish and other weeds, which saves on herbicides.

‘It is best to aim to control the broad-leaved weeds with stock.’

Nitrogen
The Stokes family think that the production of nitrogen has been a bonus ‘we haven’t decreased the amount of fertiliser we are buying but we are getting much better yields’. Looking at past soil tests with recent ones Jason has seen that soil nitrites have gone up which allows them to slowly begin reducing nitrogen inputs and to begin addressing trace elements which will help soil fertility.
Difficulties

Extra monitoring of stock and rotational grazing is required. As the Stokes have a laneway the need to move stock more frequently is not a problem but Jason says that he can see how it may be an issue on other farms without a laneway. ‘If other growers don’t have a laneway they can have volunteer pasture paddocks adjacent to the biserrula paddocks, so stock doesn’t have to be moved far’.27

Economics

‘... is difficult to put a monetary value on the biserrula as it provides long-term farming system benefits. We feel that we are producing ‘spare’ nitrogen which is reducing the amount of nitrogen that needs to be added to the paddocks’.27

‘How do you put a dollar value on the extended life of chemicals?’ 27

Interview by Natalie Hogg on 15th October 2008
‘Biserrula helps to control resistant ryegrass’
Chambers

Key messages
• A three-year non-cereal phase helps control group B-resistant ryegrass.
• The biserrula pasture tolerates more stresses than a volunteer pasture, it is able to set seed through most circumstances: dry years and heavy stocking.
• Biserrula provides some good quality early feed.

Background
Andrew Chambers and his wife Jennifer wanted to grow something on their property Yoorooga that would not require to be sown each year and would help with grazing the weeds out. Biserrula was the answer. In 2000 Andrew first tried to address the group B-resistant ryegrass with biserrula targeting the worst paddocks. He has increased to 1000 ha by sowing a new paddock each year. Rotations have varied but to get good ryegrass control Andrew suggests to withhold growing a cereal crop for two to three years.

Farm statistics
Location: Ravensthorpe
Farm size: 5000 ha
Rainfall: 400 mm
Enterprise: crop 85 %, pasture 15 %
Stock: usually 2000
Area to biserrula: 1000 ha
Soil type: duplex sand over clay, sandy gravel over clay and grey clay

That first year
<table>
<thead>
<tr>
<th>Preparation</th>
<th>Knockdown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sowing rate</td>
<td>Scarified biserrula @ 5 kg/ha and Cadiz @ 3 kg/ha (to get bulk)</td>
</tr>
<tr>
<td>Technique</td>
<td>Air-seeder</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>MAP or superphosphate @ 50 kg/ha (starter P application)</td>
</tr>
<tr>
<td>Stock</td>
<td>Stocked by September</td>
</tr>
</tbody>
</table>
**Management**

*Grazing*
Andrew has two adjacent biserrula paddocks and rotates sheep from one to the other. Weeds are available when stock is moved to the rested paddock, which lowers the chances of photosensitivity developing.

**Benefits**

*Livestock*
At one stage Andrew had 1800 lambs on 150 ha and believes that biserrula tolerates more pressure than a volunteer pasture.

*Rotation*

‘With a pasture you want to be able to do up to five years crop and still have it come back’. Andrew says that he has seen biserrula do this well, whereas subclover is declining under heavy cropping. Andrew would still grow biserrula even without sheep, he would green manure it.

*Weed control*
Andrew is finding that weed control with biserrula is successful as his ryegrass numbers are down. He has tried different rotations but feels the need to stick to three years of non-cereal in order to do a better job of controlling the resistant ryegrass (group B).

'**Biserrula is a persistent legume that I use to control resistant weeds in my intensive cropping rotation'**

**Nitrogen**

In 2007 Andrew had a mix of serradella and biserrula, which was followed by a 1.9-ton canola crop. Andrew was impressed with this as he normally has to apply more fertiliser.

**Difficulties**

‘I have had some great stands of biserrula however some have had heaps of turnip through it. To clean it up though we put the weed-wiper through it which is working well’.

Interview by Natalie Hogg on 11th February 2009
‘Improving the stocking enterprise and increasing profits’

Key messages
- One year of biserrula produced enough nitrogen for a barley and wheat crop.
- Biserrula allows easy weed control with stock, controlling up to 90 per cent of the weeds.
- It is important to monitor biserrula, not just for photosensitivity but for aphids too.

Farm statistics
- Location: Carnamah
- Rainfall: 375 mm
- Enterprise: Crop 60 %, Pasture 40 %
- Area to biserrula: 40 ha
- Soil type: grey clay to grey coarse sand loam with some gravel

Background
Biserrula was first sown by Alf Niven and his wife Maria in 1998 with the hope of finding a suitable alternative to Dalkeith subclover. Since its first year the 40 ha paddock has been biserrula, except for 1999 and 2000 when Alf grew barley and then a wheat crop maintaining yields without applying additional nitrogen fertiliser.

That first year
<table>
<thead>
<tr>
<th>Preparation</th>
<th>Knockdown prior to sowing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sowing rate</td>
<td>3 kg/ha</td>
</tr>
<tr>
<td>Technique</td>
<td>Spread seed and lime then tickled it in with combine and harrows</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>Lime @ 1 ton/ha</td>
</tr>
<tr>
<td>Stock</td>
<td>5 sheep/acre 2 weeks after sowing, with stock struggling to keep up</td>
</tr>
</tbody>
</table>
Management

Grazing
Alf believes that it is valuable to have green feed available from biserrula for an extended period at the end of the season, in comparison to subclover. He also said that he ‘... has been able to increase stock numbers, as it does not struggle with stock on it like subclover does’.

In his experience, biserrula produces more biomass than subclover.

Pest/disease
Alf believes that it is necessary to spray for aphids early when they are first observed otherwise ‘you can see your whole stand disappear’. Alf learnt the hard way in 2008 ‘we had a magnificent stand of biserrula, looked to be the best we have ever had. We had a long dry period in July-August. It looked as if the biserrula was beginning to turn so I just waited for rain. I went and checked it and realised that it was aphids, but it was too late to spray and the aphids did a lot of damage’.

Benefits

Persistence
With recent dry years, false breaks and increased summer rainfall, Alf believes that it is the hard seeds that are saving the biserrula and why it is working for his system.

Alf thinks that ‘...you don’t seem to need a lot of seeds for the biserrula to persist’. Some years we have only had around four seeds per pod, which is a disaster for harvesting reasons but it seems to hold itself for regeneration. Due to its very hard seeded nature and seeds not germinating until the second year, biserrula is able to persist well after years when there has been limited seed production.

Livestock
‘I have been able to increase stock numbers and I have the ability to ‘load it up’ with sheep when it starts to go off, so that they can get the feed’.

‘It doesn’t struggle with stock on it like subclover does. I have had more success with biserrula in regards to biomass production in comparison to subclover, which has resulted in fatter sheep where I can make some extra money’. He doesn’t doubt that Dalkeith has good biomass but when biserrula is eaten back it goes back to how it was, which is good to extend the feed available.
Farmers’ experiences with biserrula

Weed control
In Alf’s biserrula paddock the weeds are controlled with the stock, which has resulted in a change in pasture composition, with biserrula becoming dominant. However this does vary from year to year, depending on the season. Alf has seen ‘the sheep clean up 95 per cent of the weeds; they eat the cape weed down to the roots’.

Nitrogen
Biserrula in the first year produced enough nitrogen for the following two cropping years. ‘We didn’t add any extra nitrogen and they did well. It is not unusual to get a 3–4 ton crop after the biserrula if we get the rain. The nitrogen from the biserrula is worth a lot, especially with the fertiliser prices of late (early 2008).’

Difficulties
The only problem Alf has had has been with aphids. ‘On the first sighting of aphids you need to get out and spray them, as they can reduce your seed set and green biomass considerably’.

Interview by Natalie Hogg on 10th September 2008
'Using biserrula to control barley grass'

Munckton

Key messages
- Pasture composition has changed, with barley grass disappearing.
- Biserrula is producing nitrogen and the money saved from nitrogen is being used for potash which is making the whole farming system more viable.
- Biserrula is helping with the control of resistant rye grass.

Farm statistics
Location: York
Farm size: 560 ha
Rainfall: 450 mm
Enterprise: crop 60 %, pasture 40 %
Stock: 1000 sheep
Area to biserrula: 85 ha
Soil type: gravelly sand

That first year
Preparation  | Heavily grazed out all of the weeds, grass-selective herbicide
Sowing rate  | Scarified seed sown in late June
Technique    | Combine, scratched it in with DBS modules and followed with press wheels
Fertiliser   | Potash on the light country
Stock        | Grazed lightly removing stock at flowering

Background
John Munckton and his wife Joan farm a 560 ha property, Woodlands, near York. John started growing biserrula in 2004, sowing only 12 ha due to the late break to the season. The following year though John chose three dirty (weedy) paddocks and established biserrula in a mix with serradella. In the future John hopes to use the biserrula paddocks in a 'year in year out' rotation, which he has wanted to do from the beginning but because the pasture has been so good he has been reluctant too.
Management

Grazing
Grazing is the main use that John has for the biserrula paddocks. He feels that he has better quality grazing due to the biserrula. To avoid photosensitivity John has an adjacent paddock where he can move stock to.

Pest/disease
John says that you need to look out for aphids and control them if they are present.

Benefits

Livestock
'I have been able to increase stocking numbers substantially. I have doubled my flock.' John thinks this is due to better pasture management. 'We now have 500 ewes and 500 lambs on 82 ha. I also feel that the fertility has improved; they seem to be healthier overall. Wool micron has also come back a bit, which I was surprised about.'

Weed control
John's pasture composition has changed; the barley grass, which was a problem, has disappeared. The biserrula is also helping to control the resistant ryegrass, which is a huge plus.'

Nitrogen
'The money that I am saving on nitrogen I am using for potash for my pastures which overall is making the farming system more viable.'

Difficulties
The only difficulty that John has had is the control of capeweed. 'It is the only weed that I have to be worried about.'

Interview by Natalie Hogg on 30th September 2008
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