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Using biserrula to increase crop and livestock production

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Foreword

Pasture legumes have long been the backbone of pasture and crop production systems in NSW. Traditionally, this role has been fulfilled by annual legumes such as subterranean clover and various medic species. While these species were widely successful, they do suffer from some limitations including shallow root systems which restrict their ability to survive moisture stress particularly in spring which can result in poor seed set. Additionally, false breaks in autumn can seriously deplete seed banks. Drought and highly variable seasonal conditions in NSW have resulted in the depletion of these species in NSW.

New annual legume species development over the past 20 years through programs such as the National Annual Pasture Legume Improvement Program (NAPLIP), have resulted in the development of a diverse collection of annual legume species with high potential for NSW farming and grazing systems. The ability of these new legumes to provide answers to legume loss and therefore poor pasture and crop productivity is very promising.

One of the most exciting attributes of these new legumes is their ability to give farmers greater flexibility in their crop-pasture rotation systems. The productivity and reliability of these new legumes has been shown through recent drought years in NSW in comparison to traditional legumes.

Biserrula is one of these new legumes. Its ability to persist in the often dry and frequently variable seasonal conditions experienced in NSW over the duration of this and earlier projects has been outstanding. Perhaps one of the most interesting attributes of this plant is its very high hard seed levels and its potential to alter the crop-pasture rotation systems to a more flexible model that may allow farmers to more readily alter the crop to pasture and therefore crop to livestock ratios of their farms.

Dr Peter Orchard
Manager – Pastures Unit
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Introduction

Origin of biserrula

Biserrula (*Biserrula pelecinus*) is an annual legume native to the Mediterranean areas of Europe and Africa. Its range extends to cooler highland areas of Kenya, Ethiopia and Eritrea and it is also found in the Canary Islands. In its native range, biserrula is commonly found growing in association with other annual legume species such as subterranean clover (*Trifolium subterraneum*) and serradella (*Ornithopus* spp.).

Biserrula seed and nodules were first collected by Professor John Howieson and Dr Mike Ewing in 1987 from the Greek Islands, as part of a broader collection. This was followed up by a second targeted collection by Prof. Howieson in Morocco, Greece, Sardinia and Corsica in 1993.

After these 2 collections Prof. Howieson sought material from elsewhere in the world, including from a collection made by P. Beale, A. Lahlou and M. Bounejmate in 1991, to do the first agronomic assessments in late 1993. Dr. Angelo Loi, Prof. Howieson and Dr. Steve Carr at the Cooperative Centre for Legumes in Mediterranean Agriculture (CLIMA) subsequently developed these collections resulting in the release of the first commercial variety of biserrula for world agriculture in 1997.

Plant description

Biserrula is a self regenerating annual legume which can grow up to 50cm tall. Biserrula has a fern-like leaf with leaflets located opposite each other. Leaflets measure up to 10mm long and 5mm wide, though seasonal conditions can affect size. The tip of the leaflet is indented.

Biserrula has a small blue to mauve coloured flower. The seed pod of biserrula measures up to 40mm in length and 10mm in width. It has a coarsely toothed edge. The seed pod changes in colour from pale green to brown with maturity. The seed pod of biserrula contains approximately 15-20 seeds depending on variety and season (Figure 1). The seeds are yellowish-brown in colour and there are approximately 1,000,000 seeds per kilogram.

Biserrula in comparison to subterranean clover is deeper rooted and this assists in it being able to withstand moisture stress which can be commonly encountered in spring. The deeper root system allows it to better access moisture and also enables it to remain green later in the season. Biserrula unlike subterranean clover will continue to flower and produce seed pods while ever growing conditions are favourable. In New South Wales, plants have been observed to still be flowering and setting seed as late as February in some seasons.

Figure 1. Top: Flowering biserrula with green seed pods (Photo: Belinda Hackney, NSW DPI), Below: biserrula seed and seed pods (Photo: Department of Agriculture and Food Western Australia – Pasture Science Group).

Figure 2. Left to right – biserrula, French serradella, yellow serradella (Photos: Belinda Hackney, NSW DPI)

Similar species

Biserrula is similar in appearance to some other legume species. Most notably, biserrula is often confused with serradella. Serradella (both yellow and French serradella) have rounded leaflet tips whereas biserrula has a notched tip. Biserrula has blue to mauve flowers whilst yellow serradella has yellow flowers and French serradella has whitish to pale pink flowers (Figure 2). Biserrula seed pods are coarsely toothed and contain small yellow to pale brown seeds. Serradella pods have a smooth margin and when mature break into individual segments each containing one seed.

Area of adaptation

Climatic requirements

Biserrula will grow successfully in areas with an average annual rainfall of 325-800mm in NSW. Biserrula has proved to be extremely drought tolerant in recent low rainfall years in NSW and has successfully grown and set seed in such years where growing season rainfall has been as low as 90mm.

Biserrula, with its high hard seed content, is well protected against out-of season rainfall and due to its prolific root growth plants that may germinate on what would be considered a 'false autumn break' for traditional legumes and is capable of surviving long periods of moisture stress until the next rainfall event. Trials in NSW have shown that biserrula frequently survives false autumn breaks that result in the death of subterranean clover.

Soil requirements

Biserrula is well suited to growing on well drained soils with a pHCa of 4-7. It also has good tolerance of high levels of exchangeable aluminium (30%) although it is sensitive to high levels of exchangeable manganese (Mn). Biserrula is not suited to soils prone to waterlogging.

Biserrula varieties

There are two varieties of biserrula currently available – Casbah and Mauro.

- **Casbah** – was the first biserrula variety developed for world agriculture by Angelo Loi, John Howieson and Steve Carr at the Cooperative Research Centre for Legumes in Mediterranean Agriculture (CLIMA) in Western Australia from seed collected in Morocco in the early 1990's. Casbah was released in 1997.
- **Mauro** – was released in 2002 following breeding and development from material collected by Angelo Loi, Steve Carr and M. Porqueddu in Sardinia in 1995. Mauro has slightly lower hard seed levels compared to Casbah which improves regeneration in a second year pasture (Figure 3).

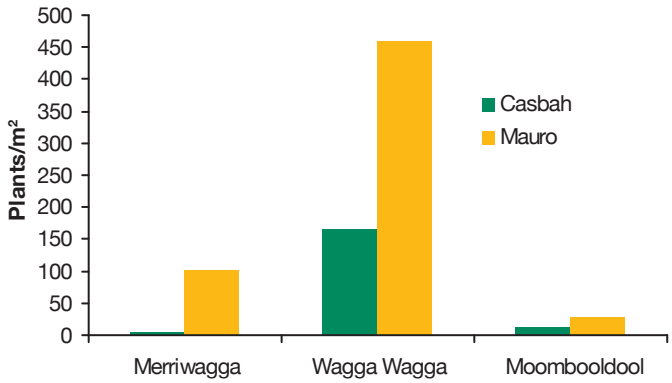

Figure 3. Second year regeneration of Casbah and Mauro biserrula at three locations in southern NSW.

Biserrula in Australian agriculture

How does biserrula compare to traditional legumes?

Biserrula has performed very well in comparison to traditional legumes such as subterranean clover in research and on-farm trials in NSW in the past decade.

Productivity

In the recent drought years, biserrula frequently produced 2.5 to 3 times more herbage compared to subterranean clover across a range of soil and climatic zones (Figure 4). Importantly, biserrula was able in these drier than average years, to set adequate quantities of seed for regeneration in the following year, whereas the quantity of seed set by subterranean clover was not sufficient for regeneration.

The ability of biserrula to remain green and productive even in very dry conditions is shown in Figure 5. This photo was taken at a Manildra site in late October 2008. The photo shows that biserrula is still green whereas the shallower rooted species balansa clover has already senesced.

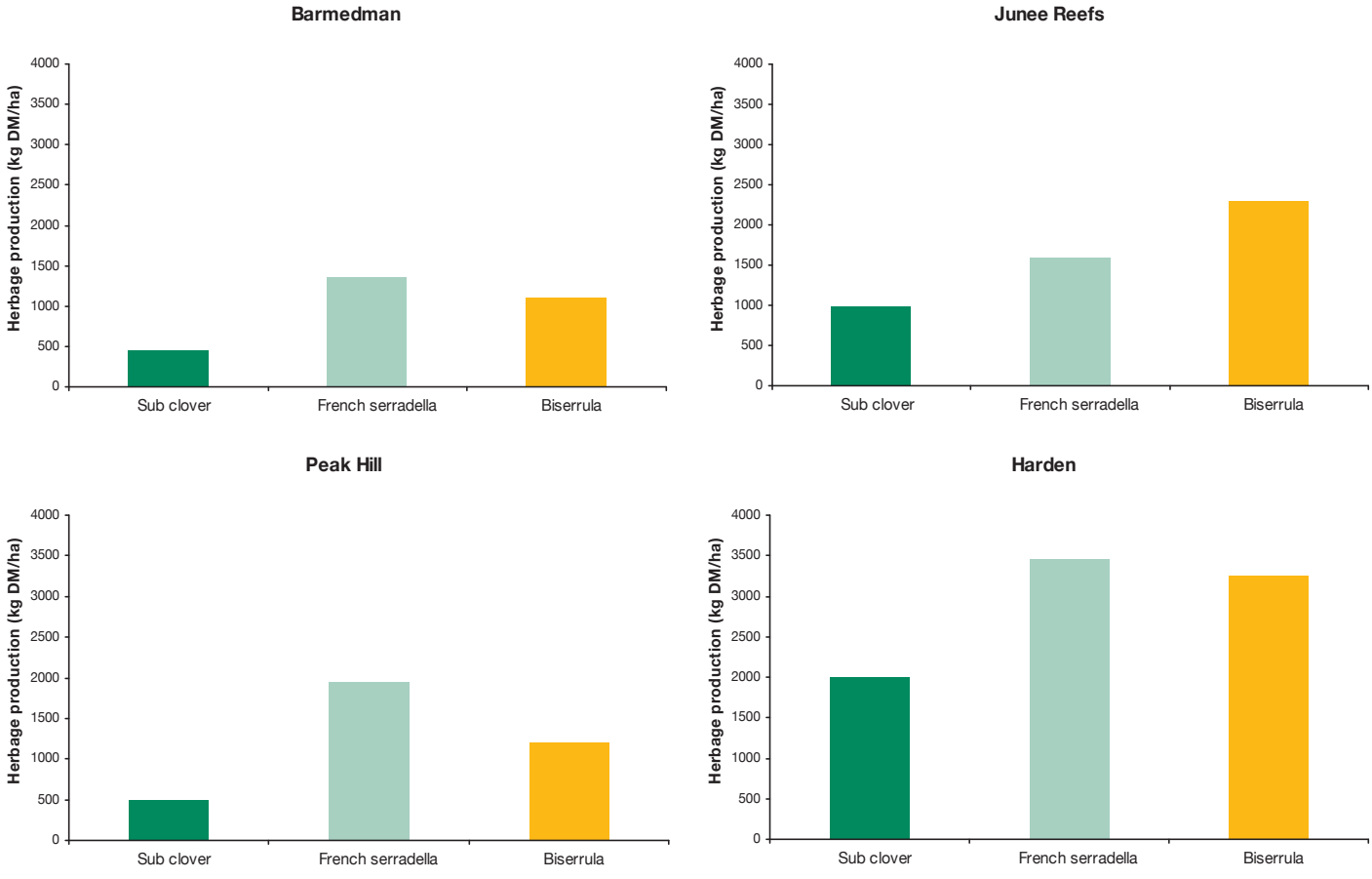

Figure 4. Herbage production of subterranean clover, French serradella and biserrula at four locations in NSW in 2008. Note: Dalkeith subterranean clover was used at Barmedman and Peak Hill, Seaton Park subterranean clover at Junee Reefs and Harden. Margurita French serradella and Casbah biserrula were used at all sites.

Figure 5. Photo above shows (left to right), biserrula, balansa clover and arrowleaf clover in late October 2008 at Manildra, NSW. Both biserrula and arrowleaf clover are relatively deep-rooted species.

In years with well above or near average rainfall, biserrula herbage production has been found to be similar to subterranean clover (Figure 6).

The advantage of biserrula however is its ability to provide herbage for grazing animals in years of low or erratic rainfall where the performance of shallower rooted species can be severely compromised.

Nutritional characteristics

Nutritionally, biserrula compares well in terms of digestibility and metabolisable energy (ME) to subterranean clover. Sequential measurements throughout spring and into mid summer, have shown that digestibility and crude protein levels were considerably higher than subterranean clover in early spring and that high levels of digestibility were maintained into mid summer (Figure 7). Crude protein levels were lower than subterranean clover early in spring, but again crude protein levels were maintained at high levels into mid summer.

Comparison of potential liveweight gain achievable on a per head basis using Grazfeed with weaner cattle showed similar results for biserrula and subterranean clover early in spring, but as the season progressed the potential weight gains from biserrula were considerably higher than for subterranean clover.

Interestingly, in this experiment, due to the early senescence of subterranean clover, there was insufficient material available for testing in January, that is the subterranean clover plant material had disintegrated whereas there was still sufficient biserrula material present in the experimental plots for sampling and analysis.

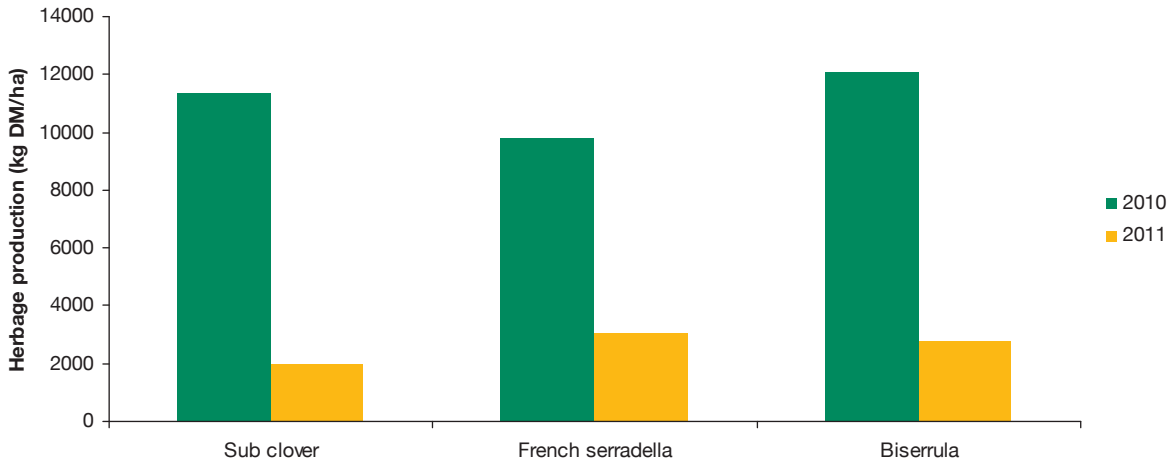

Figure 6. Herbage production of subterranean clover (Coolamon in 2010, Seaton Park in 2011), Margurita French serradella and Casbah biserrula in 2010 (well above average total and growing season rainfall) and 2011 (near average growing season rainfall) at Harden, NSW.

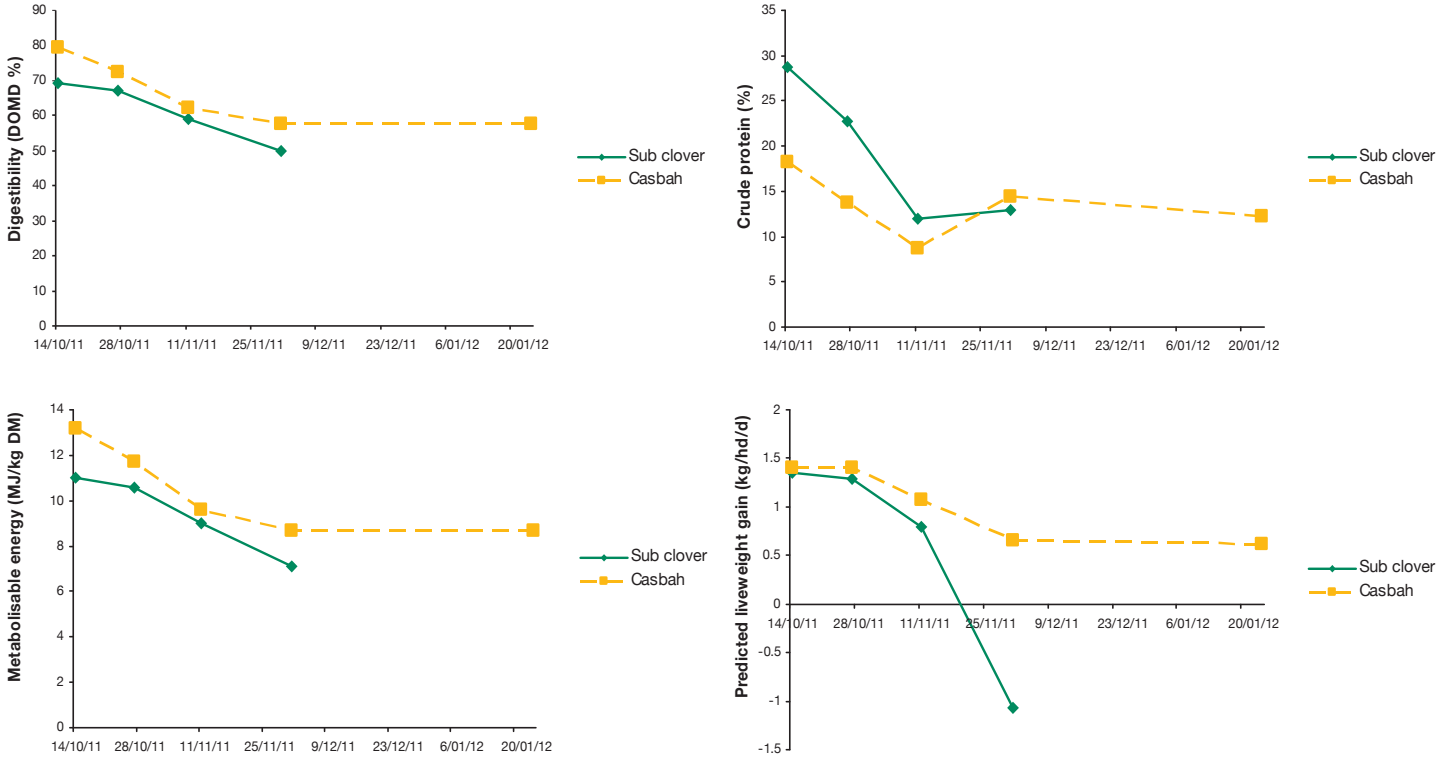

Figure 7. The digestibility, crude protein, metabolisable energy and predicted liveweight gain in weaner British bred cattle as predicted by GrazFeed for Seaton Park subterranean clover and Casbah biserrula on several occasions through spring 2011 at Harden NSW. Note there was insufficient material of subterranean clover available for collection from plots in January for quality analysis and therefore for predicted animal production.

It can initially take animals some time when first introduced to biserrula pasture to become accustomed to it. Livestock will generally tend to eat grasses initially. This preferential grazing can be used to advantage in controlling problem weeds such as annual ryegrass with sheep tending to graze it prior to grazing biserrula. This has been a successful integrated weed management (IWM) strategy used in Western Australia where annual ryegrass resistance to selective herbicides is widespread.

Figure 8. Sheep grazing a regenerating biserrula pasture

Agronomic characteristics

Hardseededness

In comparison to subterranean clover, biserrula has very high levels of hard seed. Casbah has higher levels of hard seed compared to Mauro. Immediately following seed set and senescence the hard seed content of Casbah biserrula is 99%. If seed is left in the paddock, this reduces to about 85% by May of the following autumn under Western Australian conditions. Mauro biserrula has a hard seed content similar to Casbah following seed set but it breaks down more quickly and by May has a hard seed content of about 70%. Because of its higher hard seed level, Casbah is a better choice in lower and less reliable rainfall areas.

It appears that hard seed levels and/or the rate of hard seed breakdown may be different in NSW compared to WA. In NSW, biserrula has frequently regenerated strongly (regardless of variety) in the year following sowing where this is not observed in WA (Figure 9). It is likely that higher humidity levels through summer play a role in this. Additionally, the spring finish in WA is often sharper than in NSW which promotes formation of a higher proportion of hard seed. Fully understanding hard seed break down patterns is important for persistence and understanding the differences in hard seed breakdown patterns and factors contributing to it are the planned focus of future research.

Figure 9. Second year regeneration of Casbah biserrula near Young in NSW (Photo: Belinda Hackney, NSW DPI)

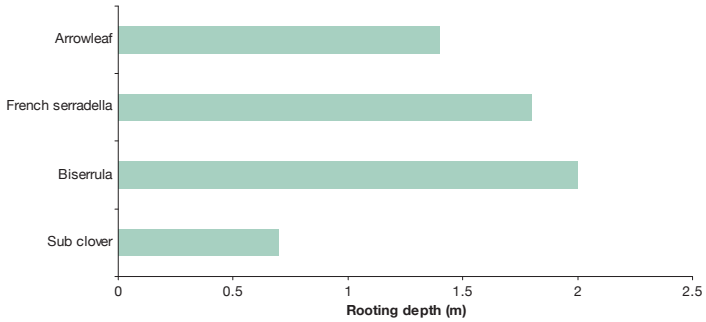

Figure 10. Rooting depth of biserrula in comparison to arrowleaf clover, French serradella and subterranean clover. Source (Carr et al. *1999)*

Rooting depth

In comparison to subterranean clover, the rooting depth of biserrula is considerably deeper (Carr *et al* 1999) (Figure 10). The more extensive rooting depth of biserrula enables it to better survive dry periods in spring. Additionally, root development of biserrula is more rapid than in subterranean clover. This means that biserrula has a higher probability of surviving what would be a 'false break' – summer or early autumn rainfall without adequate follow up rain which would kill subterranean clover seedlings.

Palatability (weed control)

Biserrula is a high protein, high quality forage with similar nutritive value to subterranean clover. As with any new forage, it can take livestock some time to become accustomed to biserrula. When introduced to biserrula, livestock will generally tend to eat grasses first. At flowering time, biserrula becomes less palatable to grazing animals. Palatability increases again once flowering ceases. The differences in palatability of biserrula and other pasture components can be used to advantage in controlling undesirable pasture components. For instance, where annual ryegrass, particularly herbicide resistant annual ryegrass, is a problem, biserrula can be used to assist in its control.

Annual ryegrass is a very high quality forage and livestock will initially graze it in preference to biserrula. Incorporation of biserrula into a pasture-crop rotation can therefore be a useful way to reduce annual ryegrass populations prior to the next cropping phase.

Using biserrula in farming systems

Which variety should I use?

There are two varieties of biserrula available in Australia. These are Casbah and Mauro. Casbah has higher hard seed level than Mauro making it more suitable for use in environments where rainfall is lower and/or less reliable. Mauro has a reduced level of hard seed, but is still significantly higher than subterranean clover. The slightly lower level of hard seed in Mauro may make it more suitable for use where higher regeneration in the second year is desired. In NSW both varieties have generally performed well with regard to regeneration across a range of climate and rainfall zones.

It should be remembered, that while the hard seed level of biserrula is high, there are approximately three times more seed per kilogram compared to subterranean clover. Therefore, even though the hard seed percentage of biserrula is high, there are still many thousands of soft seed per kilogram in regenerating stands. For example, biserrula contains approximately 1 000 000 seeds per kilogram. If 25% of this seed is soft by late autumn, then there will be approximately 250 000 seeds capable of germination per kilogram of seed set. Under NSW conditions, biserrula commonly produces around 700 kg seed/ha, this will equate to 17 500 soft seeds per square metre by late autumn.

Using biserrula in crop-pasture rotations

The combination of high feed production, deep root systems and high hard seed levels make biserrula a highly suitable species to use in crop-pasture rotations. A survey in 2009 of 300 farmers in central and southern NSW found that 80% of farmers used cover cropping as the main method to establish pastures, but only 30% believed it was a highly effective way of establishing pasture. Cover cropping involves using a low rate of cereal as a cover crop in the final year of the crop phase and sowing scarified pasture legume seed with the crop. Competition occurs between the crop and the established pasture. The other main way to establish pasture is to sow scarified seed alone.

In NSW trials these crop-pasture rotations have been most successfully established by sowing scarified biserrula seed as a stand alone pasture in year 1 and allowing it to set maximum quantity of seed (Figure 11). Cover cropping resulted in significant reduction in seed production of the legumes. Additionally seed size was also adversely affected.

Pasture production in subsequent years is a function of seed production while seedling vigour is affected by seed size, therefore any practice which compromises seed production and affects seed size will affect future pasture and therefore animal productivity.

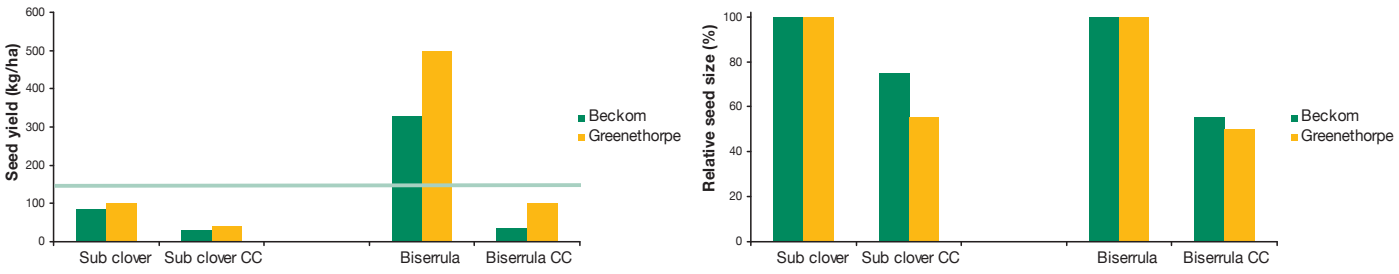

Figure 11. Seed yield (kg/ha) and relative seed size (%) of subterranean clover and biserrula established as either a stand alone sowing or sown under a wheat cover crop (CC) at Beckom and Greenethorpe in NSW. Note. Dalkeith subterranean clover was used at Beckom and Seaton Park at Greenethorpe. Casbah biserrula used at both sites. The wheat cover crop was sown at 15 kg/ha.

Other methods of establishing crop-pasture rotations

Farmers have tended to use cover cropping as a method of pasture establishment despite its highly variable results as it gives some partial cost recovery on the high cost of pasture establishment. However, the large drawbacks for pasture production in subsequent years mean that it is not a favourable way to establish pasture.

Twin sowing

Twin sowing is a method of pasture establishment developed in Western Australia by Dr Angelo Loi and Dr Brad Nutt. This process utilises the hard seed characteristics of some of the new pasture legumes to still achieve crop and pasture establishment in a one-pass operation.

Twin sowing involves using unscarified seed of a pasture legume with very high hard seed levels and sowing it with the crop in the final year of the crop phase. As the legume seed is hard, it will not germinate (or there will only be very minimal germination in the sowing year). This means that there is no competition between the crop and the pasture. In essence, the final crop year is a normal crop year with the addition of the unscarified legume seed. Crop sowing rate does not have to be reduced and therefore there is no loss of production due to lower sowing rate which is experienced in cover cropping systems.

Care needs to be taken in twin sowing as the legume seed is very small and prone to being buried too deeply. Regeneration from twin sowing using biserrula has been successful in the experiments undertaken so far compared to regeneration achieved from cover cropping (Figure 12). Winter production in particular has been much more favourable using twin sowing compared to regeneration achieved from cover cropping or the production achieved from a late sown new stand.

This experiment also showed the advantage of the hardseeded annual legumes in capitalising on early season rainfall in the regenerating year. A significant rainfall event occurred at this site (Figure 12) in 2010 in summer which resulted in the germination of some seed of the hardseeded legumes as well as subterranean clover. Much of the subterranean clover died due to high temperature and lack of follow up rain, however, the new legumes, including biserrula, survived and were able to capitalise on the next rainfall event and higher soil temperatures more favourable for growth in autumn. By comparison, the herbage production of freshly sown pasture sown in late May 2010, a typical time for pasture sowing, when soil temperatures had begun to decline was significantly lower.

Due to its very small seed size and therefore low margin of error for sowing depth, biserrula is probably the least preferred of the hardseeded legumes for use in twin sowing. Further research will give more detail on the robustness of biserrula for twin sowing in different soil types and with different sowing equipment. Twin sowing requires use of higher rates of seed than traditional scarified seed sowing as there is greater potential for seed loss due to inaccuracies in sowing depth and/or seed loss through predation.

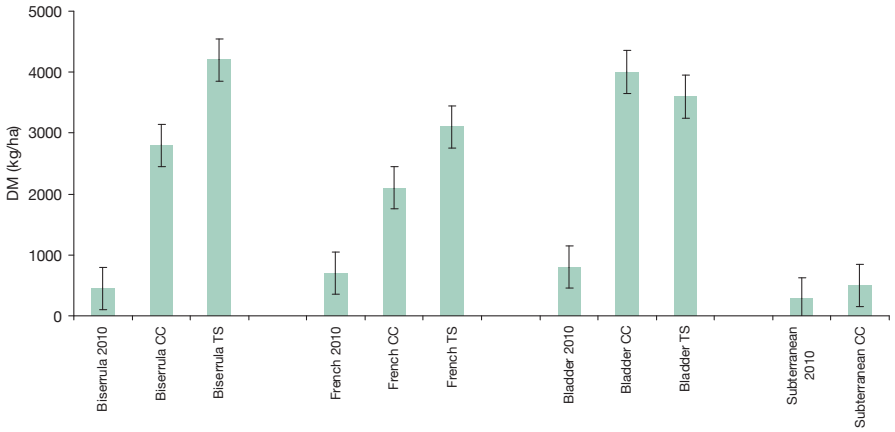

Figure 12. Winter 2010 herbage production (May to August) achieved from biserrula, French serradella, bladder clover and subterranean clover either from a May scarified seed sown in May 2010 or that achieved from regeneration of 2009 sowings established using cover cropping (CC) or twin sowing (TS)

Effective use of biserrula in crop rotations

Biserrula is a very prolific seed producer with a very high proportion of the seed produced being hard. This means there is capacity to use biserrula in self-sustaining crop pasture rotations.

Following first year seed set, most seed produced will not be germinable by the next autumn. Therefore, it is possible to crop the paddock which gives sufficient time for the seed to soften in the crop year and then remerge the following season (ie. a 1:1 pasture-crop rotation). This type of strategy also effectively utilises the nitrogen fixed by the biserrula in the cropping phase.

In NSW, it appears a higher proportion of seed breaks down over the first summer resulting in higher germination than seen in Western Australia. However, experiments have shown there is still sufficient seed carryover following a crop for successful regeneration and herbage production (Figure 13).

In Western Australia, farmers have been able to crop for up to four years following initial seed set and still have sufficient regeneration of biserrula. Further research is required in NSW to assess the apparent differences in hard seed breakdown patterns and the length of the cropping phase which can be sustained following initial biserrula seed set.

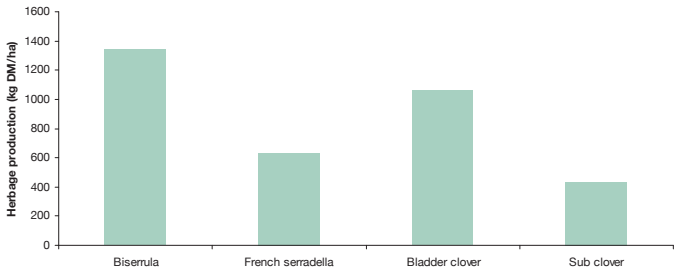

Figure 13. Herbage production in winter 2011 in biserrula, French serradella, bladder clover and subterranean clover. These were plots sown as stand alone scarified sowings in 2009, then cropped in 2010 and regenerating in 2011. Note that plots received no fertiliser in 2011.

Cropping for more than two years would likely exhaust the supply of nitrogen provided by biserrula for crops and therefore inorganic nitrogen sources would likely be needed to attain adequate crop yields should the crop phase extend beyond two years. Effectively using hardseeded legumes such as biserrula in self sustaining crop-pasture rotations appear to offer producers the capacity to reduce reliance on inorganic nitrogen sources.

Research in NSW has shown that wheat sown following a biserrula pasture with no nitrogen added produced grain with similar or higher protein levels and similar or higher yield compared to wheat sown after wheat where nitrogen had been supplied (Figure 14). This would suggest that in addition to providing high quality pasture for livestock in the pasture phase, use of legumes such as biserrula could significantly reduce expenditure on nitrogen by farmers in the cropping phase.

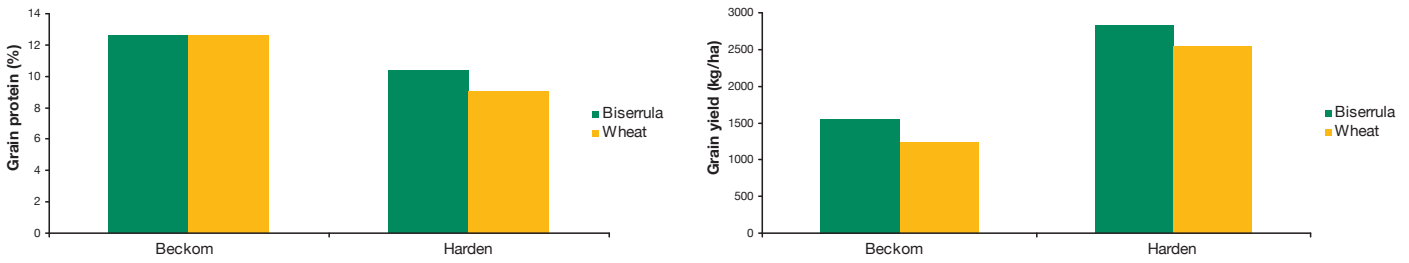

Figure 14. Grain protein (%) and yield of grain (kg/ha) of wheat sown after biserrula with no nitrogen fertiliser or wheat sown following wheat with nitrogen fertiliser (DAP at 120 kg/ha).

Using biserrula in pasture systems

Biserrula can be incorporated successfully into longer term pasture systems either with both other legume and grass species. As with other annual pasture legumes, biserrula requires light and soil contact to successfully regenerate year in-year out. To achieve this pastures containing biserrula and other annual legumes should be grazed in summer and autumn to remove excessive litter burdens. Ingestion of biserrula by the grazing animal can assist in breaking down the hard seed coat and improve germination. As biserrula is a very small seed, a high proportion (45 %) passes through the animal in a viable form (Figure 15). Livestock can be a very efficient means of transporting biserrula around the farm.

Figure 15. Biserrula seed in a sheep dung pellet (Photo: Belinda Hackney, NSW DPI)

Benefits of biserrula in farming systems

Biserrula in NSW has proved to be a very efficient plant, particularly in drier than average years. The root system of biserrula establishes quickly. This means that if out-of-season rainfall is received in summer, biserrula has a better chance of surviving compared to traditional legumes such as subterranean clover. Similarly, if rainfall in spring is low or highly variable, biserrula is better able to continue growing and set seed than traditional shallow rooted annual legumes. The ability to set seed, especially in adverse climatic conditions means that longer term persistence is improved.

The hard seed characteristics also lend themselves to setting more flexible crop-pasture rotations. Traditionally in NSW a phase crop-pasture systems has been used which is quite inflexible. Biserrula offers farmers the opportunity, once a seed bank is established to rapidly alter the crop to pasture ratio of their farming enterprise. This in turn means the crop to livestock ratio can also be altered more quickly than under traditional phase systems using traditional pasture legumes.

Establishing and managing biserrula

Selecting and preparing the site

As with the establishment of any new pasture, the area to be sown to biserrula should have been kept as free as possible of weeds for at least three years prior to sowing. This is best done by cropping the site in the years leading up to pasture sowing and keeping it as clean as possible of broadleaf and grass weeds.

Sunfonyl-urea herbicides should be avoided leading up to the sowing of pastures containing legumes and should not be used at all in the 12 months prior to sowing. Residues of sulfonyl-urea herbicides can cause root pruning in legumes which results in poor plant thrift due to reduced ability to harvest moisture and nutrients from the soil. Additionally, sulfonyl-urea herbicide residues can adversely affect nodulation as there is less interaction between the reduced plant root mass and soil rhizobia. Soil rhizobia survival is also directly affected by sulfonyl-urea residue. Poor nodulation results in poor nitrogen fixation and therefore reduced availability of nitrogen to the following crop or to other pasture components. Avoidance of sulfonyl-urea herbicides is an exclusive requirement of biserrula, all legume species can be affected by residues

Sowing requirements

Biserrula is a very small seed and requires only very shallow burial at sowing. Seed should be placed no deeper than 10mm below the soil surface and should

only be lightly covered with soil. Biserrula can be sown either into a conventional seed bed or can be direct drilled. It is not recommended that biserrula be established in a paddock by surface spreading of seed alone. Some seed-soil contact is necessary for successful establishment. If seed is dropped onto the surface of the soil, then harrows should be dragged over the surface to improve establishment. Surface sown seed is more prone to predation.

Seed sowing rates

If biserrula is to be sown as a stand alone pasture using scarified seed, rates of 6-8kg/ha should be used. If biserrula is to be used as a component of a pasture mix with either other annual legumes or perennial grasses, then rates of 1-3kg/ha are suggested.

Fertiliser requirements

Biserrula should be sown with fertiliser. At least 10kg P/ha should be applied with seed at sowing and generally a similar quantity of sulphur. Where molybdenum (Mo) deficiency is known, Mo fortified fertiliser should be used at sowing and then every one to five years following. Potassium deficiency can occur on very light sandy soils and this can reduce growth and seed set of legumes. It is always wise to soil test paddocks prior to sowing new pasture. Your local agronomist can assist you in interpreting your soil test results and attending to any nutrient deficiencies.

The importance of inoculation

Ensuring seed of biserrula is inoculated by the correct viable rhizobium at sowing time is imperative to ensuring successful establishment of a biserrula pasture. Without supply of the correct rhizobium, biserrula plants will appear pale, will lack vigour and will fail to fix nitrogen.

Biserrula requires a different type of rhizobium to subterranean clover. Biserrula was only domesticated in the 1990's for use in agricultural systems. Rhizobium required to ensure successful nodulation were developed in the domestication process. Due to its relatively short history in domestic agriculture, the only soils in Australia which have some of the rhizobium necessary to nodulate biserrula are in paddocks where it has biserrula seed that has been correctly inoculated and sown. This means that you must ensure that you inoculate any biserrula seed for sowing with the specific biserrula inoculant. Inoculant comes in several different forms.

Traditionally, peat-based slurry inoculums have been used. This type inoculant delivers very high numbers of rhizobium to the seed. Seed must be treated just prior to sowing using this technique and moisture levels in the soil need to be adequate for immediate germination to ensure that effective nodulation occurs.

Rhizobium are also incorporated into pre-coated seed. Pre-coated seed is convenient to use. However, farmers need to ensure that pre-coated seed they purchase is fresh as the rhizobium number in pre-coated seed declines with time. If seed has been coated for more than 4 weeks, the number of viable rhizobium can be very low and therefore nodulation will be reduced. It should also be remembered that coated seed has a lower number of seeds per kilogram compared to uncoated seed. Therefore, sowing rates will need to be increased to compensate for this.

In recent years, long life inoculants have been developed. These inoculants come in different forms depending on the company manufacturing them. They are sown through sowing equipment at sowing time. They can offer greater flexibility in sowing compared to traditional peat-based slurry inoculants as high moisture levels at sowing are not required at sowing when using these inoculants.

Regardless of the method of inoculation used, the penalty for not ensuring inoculation with correct rhizobium occurs is severe (Figure 16).

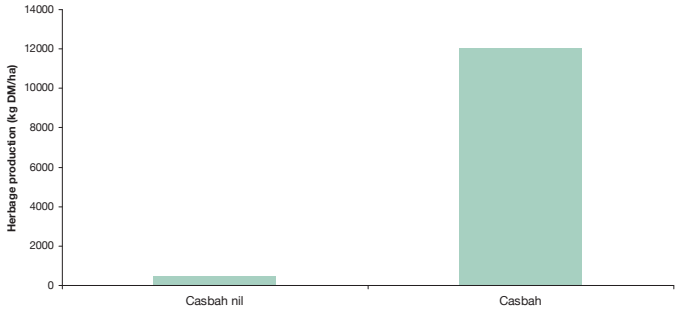

Figure 16. Herbage production (kgDM/ha) of Casbah biserrula where no inoculant was used (Casbah nil) compared to area where the correct inoculant was used.

It is wise to check sown paddocks for nodulation. Early spring is generally best. Carefully dig the plant up. Carefully wash the root system of the plant in water. Nodules on biserrula can vary considerably in shape with large clustered fan-like nodules commonly seen along with smaller rounded nodules (Figure 17). Nodules that are effectively fixing nitrogen will be pale to deep pink in colour when cut open. White and green nodules can appear on legume root systems which indicate that the nodule is occupied by another strain of rhizobium. These nodules do not effectively fix nitrogen.

Controlling weeds

As with the sowing of any new pasture, it is essential that weed burdens are reduced as much as possible prior to sowing new pasture to give maximum opportunity for successful establishment.

For biserrula, differences in palatability can be exploited to control weeds, particularly grass weeds. Livestock will preferentially eat some weeds, for example annual ryegrass, before eating biserrula.

Selective grass herbicides can be used to remove grass weeds from biserrula.

Some farmers in NSW and WA have been using blanket wipers successfully to control weeds in biserrula pastures. Blanket wipers allow differences in height of biserrula and target weeds to be exploited to control weeds (Figure 18).

Figure 17. A biserrula plant displaying an effectively nodulated root system. Note the large fan-like and smaller rounded nodules present on the root system.

Figure 18. A blanket wiper may be a useful strategy for controlling weeds in biserrula by exploiting height differences between the biserrula and target weed.

Controlling pests

Red-legged earth mite can cause significant damage to biserrula and other pasture legumes particularly during the establishment phase. It is critical that paddocks are monitored for RLEM activity prior to sowing and particularly up to the three leaf stage. Once past the cotyledon stage, biserrula has good tolerance of RLEM. Aphids can also cause significant reduction in productivity and in seed production. Control of RLEM and aphids is critical in the year of establishment to ensure adequate seed is set for future years.

Biserrula has good tolerance of lucerne flea and budworm. Control is generally only necessary where infestations are heavy.

Management for regeneration

Whether or not biserrula is grazed in the establishment year will depend largely on sowing time and growing conditions. Essentially, treat biserrula in the establishment year in the same way as a crop to encourage maximum seed set. In most years this will be no or minimal grazing in the establishment year. It is important if some light grazing does occur in the establishment year that livestock are removed just prior to flowering. This allows plants to set the maximum number of seed pods.

Once biserrula has set seed in the year of establishment, livestock can be reintroduced. It is important to graze the stand at this stage to remove excessive quantities of plant material and litter and encourage regeneration.

Biserrula is very hard seeded. Grazing and ingestion of seed will assist in hard seed break down. Approximately 45% of seed ingested by sheep will remain viable. This percentage is higher in cattle. Seed is spread in manure.

Once a biserrula stand is established it will tolerate moderate to high grazing pressure well. Grazing through winter encourages prostrate growth.

Seed production and harvest

Biserrula is an aerial seeder as opposed to subterranean clover which buries a high proportion of burrs. It is possible to harvest biserrula using a conventional cereal header and this has been done successfully by NSW and WA farmers. To achieve high seed recovery using cereal headers modification of the drum is required. Seed in commercial situations is generally harvested using suction harvesting equipment as used for subterranean clover. As the seed is set above ground, suction harvesting of biserrula is less labour intensive and less destructive on soil than harvesting of subterranean clover.

Biserrula and animal production

How does animal production from biserrula compare to other legumes?

As yet in NSW, the area sown to biserrula is quite small and actual livestock production figures on biserrula pasture is limited. Feed test results show biserrula to be of a very high quality with the forage having high protein, metabolisable energy and digestibility levels.

Modelling of animal production figures using GrazFeed show that animal production achievable from biserrula is similar to subterranean clover on a basis of kilograms of forage fed. However, given the capacity of biserrula to produce higher quantities of forage under adverse seasonal conditions, the actual animal product produced be hectare is potentially higher (Figure 19).

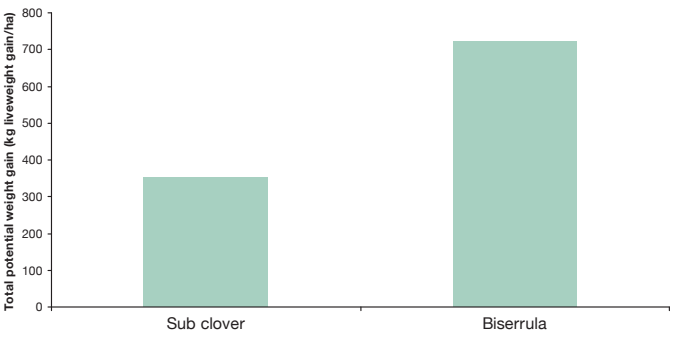

Figure 19. Potential liveweight gain (kg liveweight/ha) for herbage grown in below average rainfall year (2008) at Harden NSW.

Interestingly too, biserrula appears to retain higher plant quality later into the season compared to subterranean clover (Figure 7). This combined with its high herbage production means that animal production is potentially higher and can be maintained for longer into late spring and early summer than on subterranean clover (Figure 20).

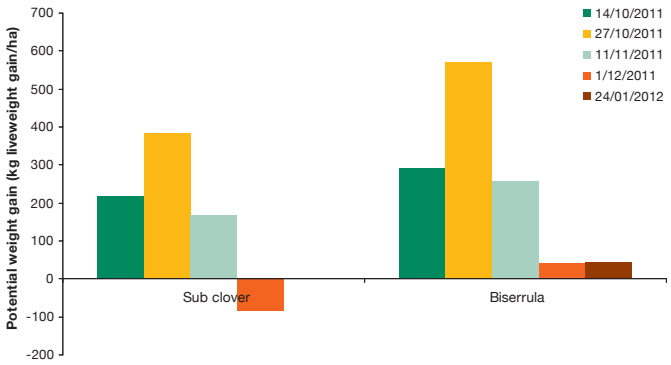

Figure 20. Potential liveweight gain per hectare from subterranean clover (Seaton Park) and biserrula (Casbah) on five possible occasions in spring-summer 2011/12 at Harden, NSW, based on yield and feed quality at that harvest date. Data modelled in GrazFeed. Note there was insufficient plant material remaining in January 2012 on sub clover plots to measure herbage on offer or to collect for quality analysis.

How can the agronomic characteristics of biserrula be used to increase animal production?

Biserrula has the potential to extend the growing season in autumn and spring. Traditional legumes such as subterranean clover are very prone to loss through false breaks in summer and early autumn. False breaks occur when rainfall received in summer or early autumn result in the germination of annual legumes. If further follow up rainfall is not received, shallow rooted plants such as subterranean clover frequently fail to survive and this is known as a false break. An example of this is shown in Figure 21 where the third year herbage production of Dalkeith subterranean clover and Mauro biserrula are compared. At this site in southern NSW where average rainfall is 460mm, false breaks which killed subterranean clover plants were experienced in the second and third year resulting in very poor third year productivity. By contrast, biserrula produced a very useful amount of herbage in the third year as a consequence of its ability to survive false breaks and as a consequence of being able to form a large seed bank with high percentage of hard seed in the first growing season.

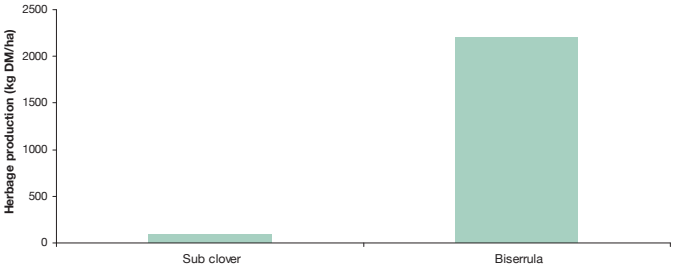

Figure 21. Third year herbage production of Dalkeith subterranean clover and Mauro biserrula where false breaks resulting in death of subterranean clover plants occurred in year two and year three.

Biserrula has a rapidly developing root system and plants which germinate on summer-early autumn rainfall have good capacity to survive until late autumn rain is received. This adaptation means that biserrula can be grazed earlier in autumn and winter than subterranean clover based pasture. Late autumn and early winter are frequently periods of feed deficit in southern Australian farming systems and therefore biserrula may enable higher levels of animal production to be achieved at this time of year.

The more extensive root system of biserrula compared to traditional legumes such as subterranean clover mean that it has the capacity to extend the growing season providing green feed later into spring and early summer. Indeed in NSW, biserrula can remain green until late December and even into late January-February in higher rainfall areas. The quality of feed for grazing livestock in this instance is higher and therefore there is greater capacity for higher animal production (Figure 5).

Photosensitisation

Photosensitisation is a condition where skin becomes abnormally sensitive to sunlight. There are two types of photosensitisation.

1. **Primary photosensitisation** can occur when animals ingest plant containing compounds that become excited by sunlight. If enough of the compound is ingested, sunlight transforms the plant compound into a toxin and skin damage results. Animals suffering from primary photosensitisation generally show symptoms within 2-3 days of ingesting plants containing toxins and begin to show signs of recovery within 4-5 days if they are removed from the source plant.

2. **Secondary photosensitisation** occurs when plant toxins ingested by livestock result in liver damage, this then results in a build up of phylloerythrin – a product of chlorophyll metabolism. On exposure to sunlight, phylloerythrin, becomes excited and damage to skin may occur. Animals suffering secondary photosensitisation often don't show symptoms until several weeks after ingesting plants. Due to liver damage, the prognosis for animals suffering secondary photosensitisation may be poor.

The first signs of photosensitisation are quite subtle and include restlessness, head shaking, rubbing and seeking out of shade. Exposed areas of skin, particularly the muzzle, ears, mulesed tails and backlines of freshly shorn sheep become red and swollen. If photosensitisation progresses the affected skin may peel off leaving underlying tissue exposed. Badly affected animals may also lose the tips of their ears and some animals may appear lame if inflammation affects the coronary band.

There are many plants including cereal crops, fodder rapes, canola, medics and lucerne where cases of photosensitisation can occur. Isolated cases of photosensitisation have been reported in sheep grazing biserrula dominant pastures.

Managing photosensitisation in biserrula pastures

The occurrence of photosensitisation in biserrula is sporadic. Where outbreaks have occurred, it has generally been in late winter and early spring when the plants are rapidly growing and approaching flowering. The pastures have also contained high proportions of biserrula (>40%). There have been no reported cases of sheep suffering photosensitisation when livestock graze biserrula residue over late spring and summer. Lambs and freshly shorn sheep are more susceptible to photosensitisation from biserrula than older stock or those with good wool coverage. To minimise the occurrence of biserrula, farmers should consider the following:

1. Rotationally graze paddocks during the high risk period – in late winter and early spring and approaching flowering rotate sheep from biserrula to other pastures. Preferably rotate animals from biserrula to grass dominant pastures in this period.

2. Feed sheep hay while they are grazing biserrula in the high risk period.

3. Avoid grazing biserrula in the high risk period with lambs or freshly shorn sheep.

Farmer experience with biserrula

Farmer name: Mike and Velia O'Hare
Location: Beckom, NSW
Long term average rainfall: 400mm
Farming enterprises: Winter cropping, meat sheep
Variety sown: Casbah

Reason for move to new legumes: Pastures have always been an important component of the crop rotation and for animal production. Traditionally, pastures were based on subterranean clover, but these have gradually declined in the past 20 years due to variable seasons, particularly short springs restricting seed set and false breaks in summer further depleting soil seed reserves. A new alternative that could cope with variable seasons was required.

Why biserrula: I had seen trial results on biserrula performance in local areas as well as areas in WA. Small areas were sown in 2009 which was a very poor year in southern NSW with rainfall in the growing season 50% below average. The biserrula did surprisingly well in that year. Although herbage production was low, it showed tremendous ability to set seed. It should be noted that sub clover failed to produce anything worthwhile herbage wise that year and it didn't survive to set seed. In early 2010 the paddock was harrowed and allowed to regenerate. Regeneration of the biserrula was outstanding and seed was harvested from it using a header. The seed produced was then used to sow a 20 ha paddock in 2011 which then went on to produce 0.7 t/ha seed. Some seed was sold and some retained for on-farm use. Biserrula is a tough plant that is fairly easy to grow and incredibly tough especially in bad years

Any problems: Biserrula doesn't have much tolerance to broadleaf weed herbicides. A weep wiper was made in 2010 which has proved to be useful for controlling weeds not only in biserrula, but also in other crops- for example taking wild oats out of barley late in the season. Photosensitisation is a concern – biserrula would be sown much more widely over the farm if the factors causing it and control of it were better understood. There has been no incidence of photosensitisation on biserrula on the farm

How do you think you will use biserrula in the future?: Biserrula will be a good fit in crop-pasture rotations. It is very tough and its ability to set a lot of seed and survive a cropping phase are very valuable traits. Knowing that the seed bank will be there and therefore being able to alter the crop:pasture ratio on farm from year to year is a tremendously valuable tool to have.

Figure 22. Biserrula established at Mike and Velia O'Hare's Beckom property in 2009, a year where growing season rainfall was 50% of average (photo on left), same paddock shown in spring 2010 (photo on right) following regeneration from seed set in 2009. (Photos: Belinda Hackney, NSW DPI).

Farmer name: Ian Westcott
Location: Peak Hill, NSW
Long term average rainfall: 400mm
Farming enterprises: Winter cropping, merino and meat sheep
Variety sown: Casbah

Reasons for move to new legumes: Traditionally the pastures on the property have been based on sub clover and medics. However, due to a long run of poor and highly variable seasons, sub clover and medics have largely disappeared from the pastures. Also sub clovers are expensive. This wouldn't be a problem if they persisted, but when they disappear within a few years of sowing there is a need to look at alternatives, particularly to maintain sheep production and to provide nitrogen to crops.

Why biserrula: Originally a small paddock near the house was sown with biserrula in 2009 which was a fairly low rainfall year. The biserrula did very well considering the season and produced about 600 kg seed/ha. While it would probably have been a good idea to crop the paddock the next year, it was a small paddock and not easy to sow with large gear. Despite biserrula having a very high hard seed content, the regeneration was excellent. The paddock was grazed by sheep most of the year, but in spring there was more than 3.5 t DM/ha on the paddock. The toughness of biserrula and its ability to grow and set seed in poor years is particularly attractive.

Figure 23. Ian Wescott, Peak Hill and Peter Yelland, Parkes in a regenerating biserrula pasture on Ian Wescott's property. (Photo: Belinda Hackney, NSW DPI).

Any problems?: There aren't many herbicide options for biserrula, although there are ways of getting around that such as using wipers and using animals to clean up the weeds when the biserrula is going through its less palatable phase. It probably isn't as easy to harvest seed as with some of the other new legumes

How do you plan to use biserrula in the future?: Biserrula will have a fit in cropping rotations and also in permanent pasture situations in some of the rougher non-cropping country.

Farmer name: Jim Gummer
Location: Junee Reefs, NSW
Long term average rainfall: 525mm
Variety sown: Mauro

Reasons for move to new legumes: Looking for a pasture legume with high productivity and ability to survive through drought and variable seasons. Sub clovers were the mainstay of pastures but they had become less reliable due to seed bank run down as a result of false breaks and poor spring conditions resulting in unreliable seed set

Why biserrula?: Reports said it had deep root systems and could survive tough conditions and was also very productive. It has proved to be so, particularly in the very low rainfall years of 2008 and 2009 when subclover failed to produce any useful feed. It has also been moving around the farm through livestock and is starting to come through in other paddocks. It has also moved into other paddocks when there has been water running across the paddocks.

Hay was cut to make from the paddock in 2011. The windrows were magnificent and potential yield was very high, unfortunately there was a very heavy sustained rainfall event and the hay was spoiled, but it has excellent potential as a hay and silage crop in addition to grazing.

Any problems?: No

How do you plan to use biserrula in the future?: Continue to use it as a self-regenerating pasture and potentially incorporate it more into cropping rotation.

Figure 24. Jim Gummer's regenerating Mauro biserrula paddock pictured as a regenerating stand in 2009 growing season rainfall was only about 90mm. This paddock still managed to set seed and provide useful feed in that year.

Farmer name: David Lee
Location: Barmedman, NSW
Farming enterprises: Winter crop and sheep
Variety sown: Casbah

Reasons for move to new legumes: Sub clover had been the main legume used on the farm. However it had largely disappeared due to drought and variable seasons running down seed reserves. Needed an alternative legume to fill the role of providing nitrogen for crops and quality feed for sheep. The hardseeded nature of biserrula appeared to offer more flexibility in a crop-pasture rotation than what could be done with sub clover. The first year biserrula was sown (2008) was a very dry year. That year the biserrula produced about 1.8t DM/ha while any of the surrounding sub clover paddocks produced less than 500kg DM/ha and had died by late September due to very dry conditions. The biserrula went on to produce a lot of seed. That year proved how tough biserrula was.

Why biserrula?: It is tough, deep rooted, produces a lot of seed and offers greater flexibility in cropping rotations.

Any problems?: Not really – it is a bit more difficult to harvest than the other aerial seeding legumes.

How do you plan to use biserrula in the future?: As part of our crop-pasture rotations.

Figure 25. Craig Rodham (formerly NSW DPI), Dr Angelo Loi (Department of Agriculture and Food Western Australia) and David Lee in a biserrula pasture sown in 2008 on David's property near Barmedman.

Farmer name: John Rodham
Location: Uranquinty, NSW
Long term average rainfall: 525mm
Farming enterprises: Winter crops, sheep
Variety sown: Casbah

Reasons for move to new legumes: Reliability of herbage production from sub clover has been poor in the last 10-15 years as the result of drought and highly variable seasons. Something that was more persistent and able to cope with these type of conditions was needed. Alternatives to lupins were also required as their productivity and economic return was really variable. Fertiliser prices for crops have continued to rise so a legume that could reliably supply nitrogen for crops as well as providing good quality feed in non-crop years without the need for resowing was very attractive.

Why biserrula?: The agronomic characteristics of biserrula seemed to fit the environment, soils and type of rotations being run on the farm. Results from trials in the local area also showed it was performing well.

Any problems?: We did have a problem with photosensitisation in lambs in the second year that biserrula was grown. I think that it is important that there is further research on this to pin point what causes these outbreaks and on better ways to avoid or manage the problem. If this is overcome, we would certainly increase the use of biserrula as it is an incredibly tough and productive plant.

How do you plan to use biserrula in the future?: Biserrula will have a fit in our crop-pasture rotations providing nitrogen for crops and feed for sheep in the non-crop years. It also has a lot of potential for silage and haymaking.

References

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