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Using French serradella 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.

French serradella is one of these new species. Breeding programs have developed varieties within this species with different hard seed characteristics which offer farmers flexibility depending on the type of crop-pasture rotation or permanent pasture system they wish to attain. This information package provides very useful information to farmers and their advisors on how to incorporate French serradella into NSW farming systems.

Dr Peter Orchard
Manager – Pastures Unit
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Introduction

Origin of French serradella

French serradella (*Ornithopus sativus*), also known as pink serradella, is an annual legume native to the Mediterranean region. French serradella is very closely related to other serradella species such as yellow serradella (*Ornithopus compressus*) and in its native region is often found growing in association with yellow serradella and other annual legumes such as subterranean clover (*Trifolium subterraneum*), gland clover (*T. glanduliferum*) and biserrula (*Biserrula pelecinus*).

French serradella was domesticated for agriculture and widely grown throughout Europe in the middle ages, including extensively through France, hence the development of its common name. However, it has only relatively recently made a comeback in modern agriculture mainly through the efforts of Australian plant breeders. The other common name for French serradella, pink serradella, is actually misleading as plant collections of *O. sativus* from around the world show great variation in flowering colour, including white, red and blue. In fact, in commercial varieties, it is not uncommon to encounter occasional red or white flowers in French serradella stands.

In comparison to yellow serradella, French serradella is easier to harvest and extract seed from the pod segments. For this reason, seed cost of French serradella is lower than for yellow serradella. French serradella was first released in Australia in 1997. The first variety was completely soft seeded. Following its Australian release, French serradella was grown mainly in association with yellow serradella as a strategic way to reduce pasture establishment costs. The French serradella acted as cheap 'filler' in the sward while the seed bank of the more expensive yellow serradella increased. As the first variety of French serradella was completely soft seeded, it would generally disappear from the pasture sward within two to three years.

Recent breeding efforts by Australian plant breeders have resulted in the development of French serradella varieties with higher levels of hard seed and/or differing maturity times to suit a wider range of agronomic conditions and farming system uses.

Figure 1. Flowering French serradella (Photo: Belinda Hackney, NSW DPI) on top, Seed pods, pod segments and seed on bottom (Photo: Department of Agriculture and Food Western Australia – Pasture Science Group).

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

Plant description

French serradella has fern-like (pinnate leaves). Leaflets are arranged opposite and usually measure up to 10mm in length and 3-4mm in width, though growing season conditions can affect this. Leaves and stems are covered in fine hairs.

Flowers of French serradella are pale pink in colour. There may also be an occasional plant which will produce a deep pink to red coloured flower, but this is quite rare in commercially available varieties. Seed pods are usually slightly curved and measure 15-40mm long and up to 5mm wide. On maturity these pods break into individual segments. The segments contain seed which is about 3mm x 1.5mm and yellow to red-brown in colour depending on variety. There are about 400,000 seeds per kilogram (Figure 1).

French serradella, in comparison to subterranean clover, is deep 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. French serradella is an indeterminant flowering species meaning that it flowers over a longer period than species such as subterranean clover which have a determinant or set flowering period. This characteristic means that French serradella is better able to respond to seasonal variation ensuring more reliable seed set, particularly when combined with its deeper root system which makes it less prone to spring moisture stress.

Similar species

French serradella is similar in appearance to some other legume species. Most notably, yellow serradella and biserrula are often confused with French serradella. Serradella (both yellow and French serradella) have rounded leaflet tips whereas biserrula has a notched tip. French serradella has pale pink coloured flowers whereas yellow serradella has yellow flowers and biserrula has blue to mauve flowers (Figure 2). French serradella seed pods are generally only slightly curved and break easily into segments at maturity whereas yellow serradella seed pods, particularly those of the older varieties, can be much more hooked in appearance and don't segment as readily as French serradella. Serradella pods, both French and yellow have a smooth margin and when mature break into individual segments each containing one seed whereas biserrula seed pods are coarsely toothed along both edges, papery in texture and relatively flat.

Area of adaptation

Climatic and soil requirements

French serradella will grow successfully in areas receiving 375 – 800mm average annual rainfall in NSW. In recent drought years, French serradella has performed very well in comparison to subterranean clover throughout the mixed farming and higher rainfall zones of NSW.

French serradella grows best in soils with sandy to clay-loam textures with pHCa of 4 – 7. It also has good tolerance of high levels of exchangeable aluminium of up to 30%, though it will generally show production increases in such soils with application of lime.

While very tolerant of high levels of exchangeable aluminium, French serradella is relatively sensitive to high levels of exchangeable manganese (Mn). Manganese levels vary considerably throughout the seasons, usually reaching a peak in late summer-early autumn when the soil is dry. This is the best time to test for manganese levels. Manganese should be tested as part of the cation exchange capacity to ascertain whether levels may impede serradella growth. Level of manganese greater than 0.30 meq/100g may indicate possible toxicity problems which may affect French serradella growth. Contact your agronomist for further information.

French serradella should not be grown in areas that are prone to waterlogging and it is not suitable to grow on saline or sodic soils.

French serradella varieties

There are several varieties of French serradella currently available:

- **Cadiz** – was developed by the Department of Agriculture, Western Australia from material collected in South Africa. Cadiz was released in 1997. It is a completely soft seeded variety. This means it is very useful as a one year crop, for example as a one year break in a crop rotation to provide high quality forage and/or provide nitrogen and a disease break for a following crop. Owing to its low level of hardseededness, Cadiz was popular when first released to use in combination with the more expensive and difficult to harvest yellow serradella as a means of reducing pasture establishment cost. Incorporating Cadiz into the pasture mix meant that herbage production in the first 1-2 years would be high and by the time Cadiz disappeared from the pasture mix, as it had no protection from false breaks, there would be sufficient yellow serradella seed in the seed bank to provide a strong long term productive pasture. Cadiz is a mid season maturing variety, flowering about 125 days after sowing making it similar in maturity to Seaton Park subterranean clover.
- **Eliza** – was developed by Dr Brad Nutt of Department of Agriculture and Food Western Australia from selections taken from Cadiz. Compared to Cadiz, Eliza flowers approximately one month earlier. It also produces a greater bulk of herbage earlier in the season. This makes it better suited to lower rainfall areas, or areas where feed is required earlier in the season. Eliza, like Cadiz, is an almost completely soft-seeded variety and therefore it is a useful component of a short term pasture or for strategic use as a break crop in a cropping rotation. Eliza was released in 2010.
- **Margurita** – was developed by Dr Brad Nutt of the Department of Agriculture and Food Western Australia and evaluated in the National Annual Pasture Legume Improvement Program prior to its release in 2004. Margurita was developed from Cadiz and has a hard seed content of around 55%. Margurita has a more upright growth habit than some other French serradella varieties. It has a similar flowering time to Cadiz and due to its higher hard seed content, it has much higher persistence than Cadiz. This makes Margurita useful as a component of longer term pastures and in 1:1 pasture-crop rotations.
- **Erica** – was developed concurrently with Margurita from selections out of Cadiz. In respect to flowering time and hard seed levels, it is similar to Margurita. Erica is a more prostrate variety than Margurita. Like Margurita, Erica is well suited to longer term pastures or in 1:1 pasture-crop rotation systems. Erica was released in 2004
- **Grasslands Koha** – is a soft seeded, very late maturing French serradella developed in New Zealand. Due to its late maturity, it is better suited to higher rainfall areas. Due to its low hard seed levels, Grasslands Koha will generally be a short term pasture species as it is highly susceptible to seedling loss via false breaks.
- **Serratas** – is a soft seeded variety of French serradella developed in Tasmania from germplasm collected in Patagonia by Bob Reid. It is reputed to have very good cold tolerance. Due to the low level of hard seed, Serratas would be susceptible to seedling mortality as a result of false breaks.

Table 1. Comparison of French serradella varieties

	Cadiz	Eliza	Margurita	Erica	Grasslands Koha	Serratas
Maturity	Mid	Early	Mid	Mid	Late	Late
Days to flowering	125	100	121	121	–	175
Hard seed level	Low (5%)	Low (5%)	Moderate (55%)	Moderate (55%)	Low (0%)	Low (0%)

French serradella in Australian agriculture

How does French serradella compare to traditional legumes

French serradella 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, French serradella frequently produced 2.5 to 3 times more herbage compared to subterranean clover across a range of soil and climatic zones (Figure 3). Importantly, French serradella 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.

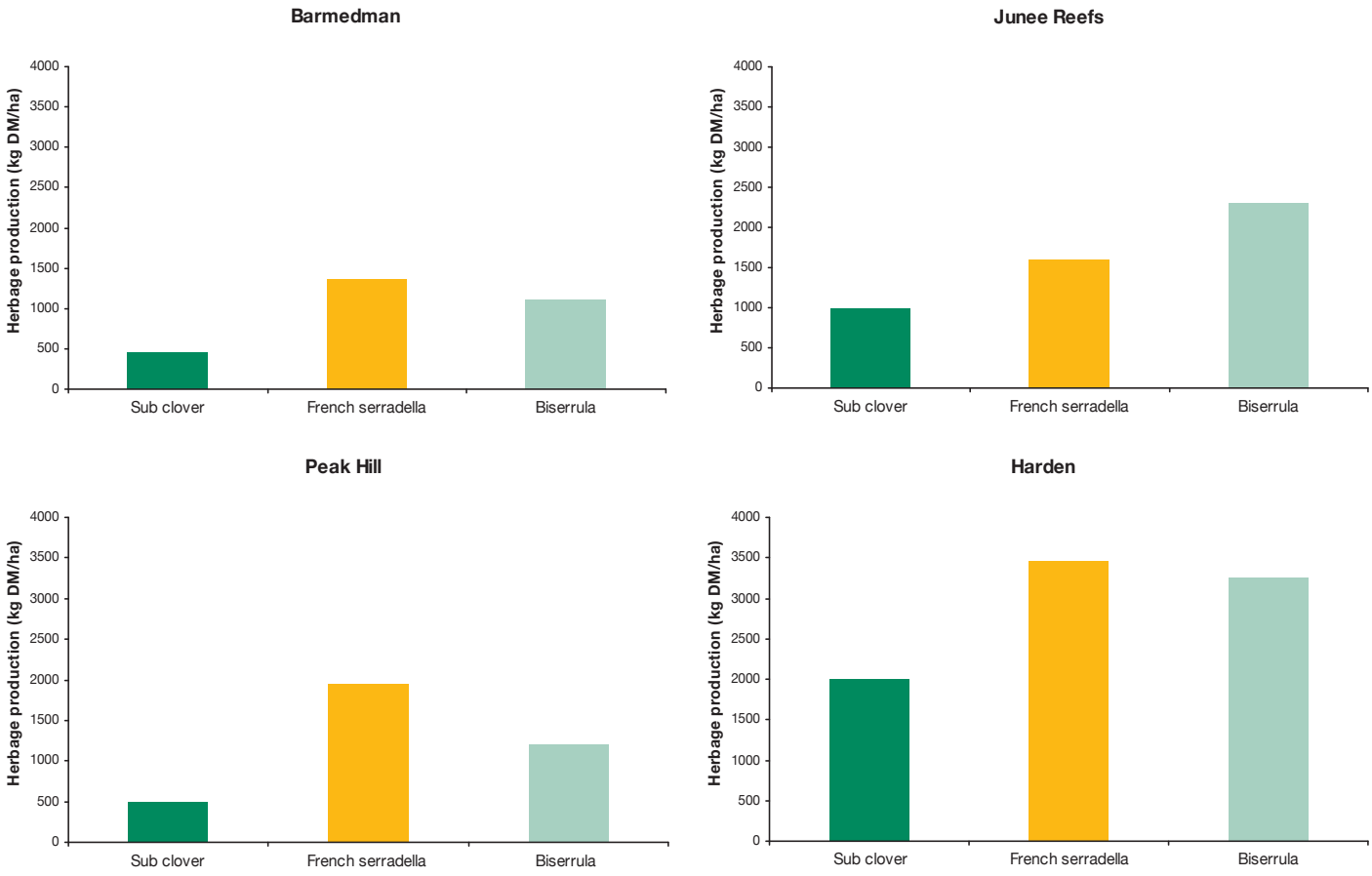

Figure 3. Herbage production of subterranean clover, French serradella and biserrula at four locations in NSW in 2008. Note: Dalkeith subterranean clover was used at Barmedman and Peak Hill, Seaton Park subterranean clover at Junee Reefs and Harden. Margurita French serradella and Casbah biserrula were used at all sites.

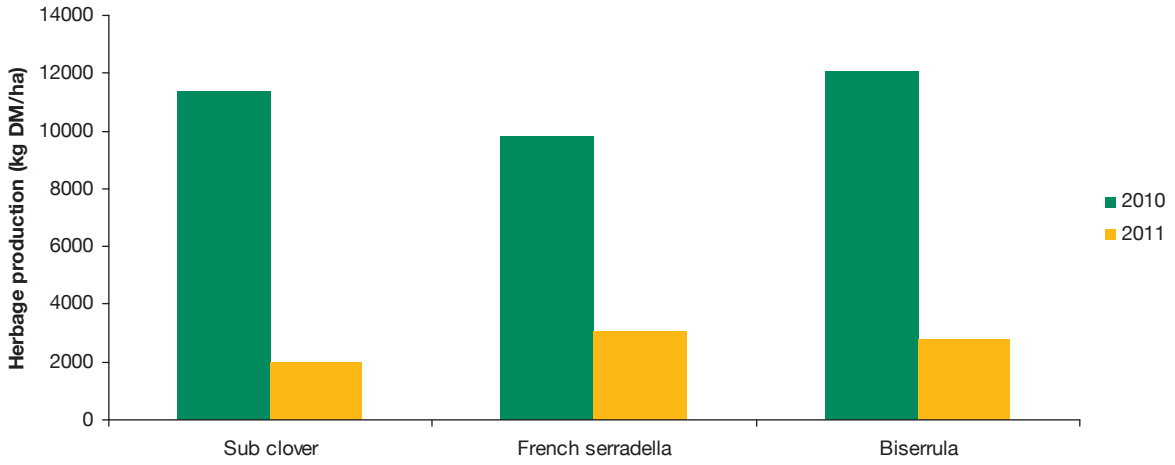

Figure 4 Herbage production of subterranean clover (Coolamon in 2010, Seaton Park in 2011), Margurita French serradella and Casbah biserrula in 2010 (well above average total and growing season rainfall) and 2011 (near average growing season rainfall) at Harden, NSW.

In years with well above or near average rainfall, French serradella herbage production has been found to be similar to subterranean clover (Figure 4).

The advantage of French serradella 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, French serradella 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, crude protein and metabolisable energy were equivalent to that of subterranean clover from early spring through until early summer (December). Due to the early senescence of subterranean clover, there was insufficient material to collect for analysis in mid summer (January). However, the French serradella collected in January had maintained the early summer digestibility, crude protein and metabolisable energy levels. Potentially, this means that animal production could be maintained at similar levels through the summer period on French serradella residues.

Comparison of potential liveweight gain achievable on a per head basis using Grazfeed with weaner cattle showed similar or slightly higher potential animal production on subterranean clover and French serradella over the spring period (Figure 5). By the fourth harvest in early summer (December), the quality of both subterranean clover and French serradella was insufficient to maintain growth – in fact by that stage animals would have been losing weight on both pastures. Samples taken in mid summer (January) showed that young cattle grazing being fed serradella at that time would have been gaining approximately 200 g/head/day. The change from predicted weight loss in early summer to slight predicted weight gain on French serradella is most likely due to the complete formation of seed pod over this period and a higher proportion of pod relative to senesced herbage in the analysed sample. Research by Department of Agriculture and Food Western Australia have shown that French serradella pods contain relatively good balance of energy, protein and digestibility. No data on subterranean clover was available for mid summer as there was insufficient material remaining on plots to be collected for analysis due to its early senescence and breakdown.

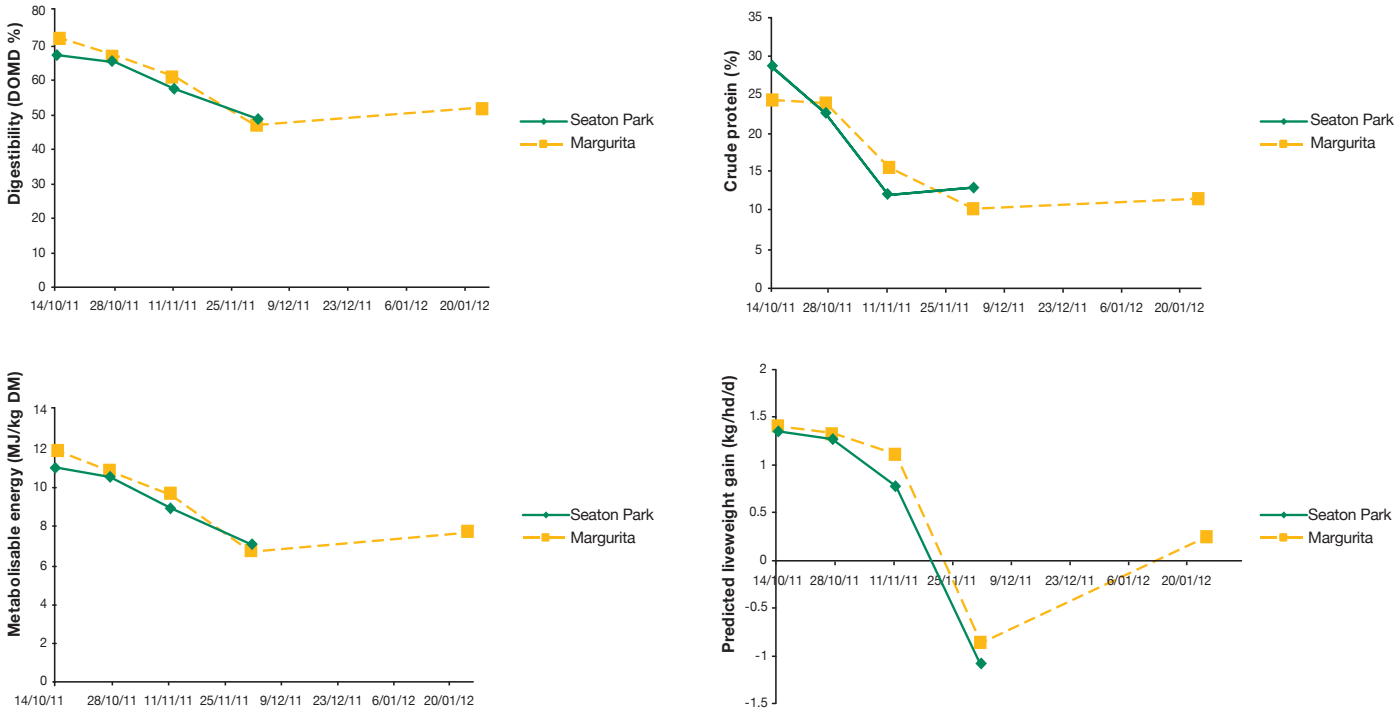

Figure 5. The measured digestibility, crude protein, metabolisable energy and predicted daily liveweight gain in British bred weaner steers (base body weight 240kg) from Grazfeed modelling in Margurita French serradella and Seaton Park subterranean clover on several occasions in spring 2011. Note: there was insufficient material of subterranean clover to collect for feed quality testing in January, therefore only four sampling times shown for subterranean clover.

French serradella is readily accepted by grazing livestock. Observation of small plot studies in NSW have shown that French serradella is generally the first species selected by grazing animals on introduction to plot areas.

Agronomic characteristics

Hardseededness

Hard seed levels vary between French serradella varieties (refer to Table 1). It is important to choose a variety that will suit your intended use. Soft seeded varieties will generally only last 1-2 years in a pasture system. Where longer persistence is required, choose varieties with higher hard seed levels. The importance of hardseededness for reliable regeneration is shown in an experiment near Wagga Wagga in southern NSW (Figure 6). Here, the soft seeded French serradella was sown along with the varieties Margurita and Erica which have higher hard seed levels. Dalkeith subterranean clover was also included in the experiment. All plots were allowed to set seed in the first year. In January of the following year, a significant rainfall event occurred resulting in germination. The plots were then sprayed out using glyphosate to determine the potential of the seedbank of different varieties to subsequently regenerate at the true autumn break. The very soft seeded Cadiz showed considerably lower autumn germination than the harder seeded Margurita and Erica and subsequently lower herbage production in the second year.

Larger scale farmer sowings have backed up the measurements taken in research experiments. Figure 7 shows farmers inspecting a paddock of regenerating Margurita French serradella in 2010. This pasture was established in 2009 which was a very dry year with rainfall in the growing season only about 50% of the long term average.

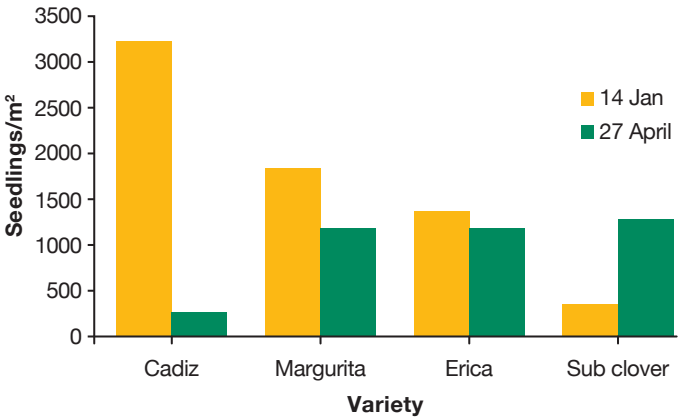

Figure 6. Second year regeneration of Cadiz, Margurita and French serradella and sub clover following a rainfall event in January. Plots were then sprayed out and germination measured again following the autumn break in April. Note Dalkeith sub clover used.

Rooting depth

In comparison to subterranean clover, the rooting depth of French serradella is considerably deeper (Carr *et al* 1999) (Figure 8). The more extensive rooting depth of French serradella enables it to better survive dry periods in spring. Additionally, root development of French serradella is more rapid than in subterranean clover. This means that French serradella 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.

Figure 7. Farmers inspecting a paddock of Margurita French serradella regenerating strongly in 2010 following a very dry establishment year in 2009.

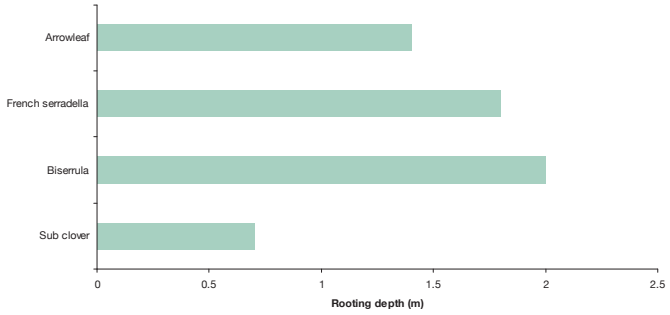

Figure 8. Rooting depth of French serradella in comparison to arrowleaf clover, biserrula and subterranean clover. Source: Carr et al. *(1999).*

Further, due to the deep root system of French serradella, it has greater ability to remain green and survive periods of spring moisture stress and continue to grow. An example of this is shown in Figure 9 where severe moisture stress was encountered in mid October 2008. Within a two week period, shallow rooted species such as balansa clover fully senesced while French serradella remained green.

Using French serradella in farming systems

Which variety should I use?

There are several varieties of French serradella available in Australia. The varieties as discussed previously vary in maturity time and hard seed levels. The best variety to choose will depend on your environment and the purpose you wish to use them for.

Soft seeded varieties are well suited to use as one year break crops. They can also be useful in adding bulk to a longer term pasture initially where perhaps the cost of longer term species is high and can be built up over a number of years. For example, soft seeded French serradella can be used in conjunction with yellow serradella. Yellow serradella seed is difficult to extract from the pod making seed costs high. French serradella, by comparison is easier to extract and cheaper to purchase. Sowing soft seeded French serradella with a lower rate of yellow serradella than would normally be used allows high initial pasture productivity. By the time soft seeded French serradella has disappeared from the stand the harder seeded yellow serradella seed bank has built up to a high enough level for reliable regeneration.

Harder seeded varieties are better choices where longer term persistence is required – for example, as a component of a long term permanent pasture. The higher hard seed levels mean greater protection and more reliable regeneration in variable season.

For self sustaining pasture-crop rotation systems, the higher hard seed varieties Erica and Margurita should be used. These varieties have sufficient hard seed to survive a year of crop and then regenerate in the following year. Such a system can considerably reduce the need for nitrogen fertiliser as well as providing a disease break and high quality grazing in the pasture year.

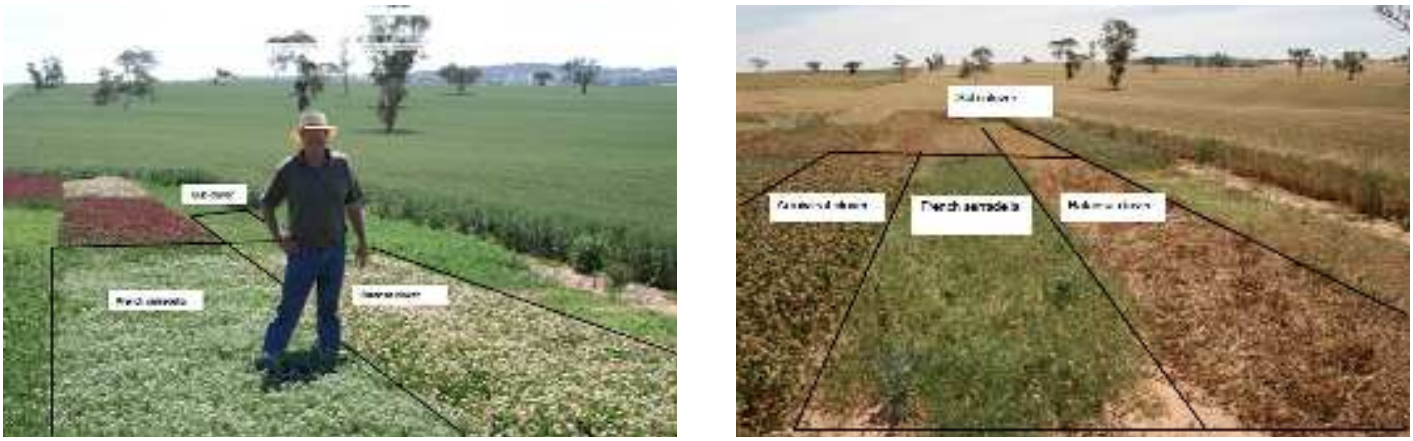

Figure 9. French serradella, balansa clover, and subterranean clover in an experiment at Harden, NSW in 2008. Photo on left taken in early October, photo on right taken two weeks later. Photo on left shows John Piltz, Ruminant Nutritionist, NSW DPI, Wagga Wagga. (Photos: Belinda Hackney, NSW DPI).

Using French serradella in crop-pasture rotations

French serradella is potentially a very useful species to use in crop-pasture rotations. How it is used depends on the variety of French serradella chosen.

Soft seeded varieties can be used as a break crop in a crop rotation. These varieties, as they are, or are almost, completely soft can be sown as segmented pod and will germinate as soon as sufficient rain falls to stimulate germination. These varieties can be grazed through the pasture phase, or can be used simply for the purpose of nitrogen fixation. These varieties will require resowing after each crop as there will be insufficient hard seed carry over for vigorous pasture growth following the crop. The soft seeded varieties are utilised by some continuous crop producers in Western Australia as a means of reducing weed burdens in fallow paddocks while supplying nitrogen for crops. The paddocks can be sprayed out early in spring to assist in moisture conservation for the following crop or if they do go through to set seed, there is virtually no hard seed and therefore any germination can be controlled prior to sowing the next crop.

By contrast, the higher hard seed varieties, Margurita and Erica, can be used as part of a self sustaining crop-pasture rotation. These varieties have sufficient hard seed, once a seed bank is established to survive on a year of cropping and then regenerate in the following year. This type of crop-pasture rotation may allow farmers to reduce reliance on inorganic nitrogen sources for crops by utilising that fixed by the legume. Additionally, a high quality pasture is available for livestock production in the pasture year.

Establishing a self-sustaining crop-pasture rotation with the higher hard seed varieties can be achieved in a number of ways:

1. **Stand alone sowing of scarified seed** – this method of pasture establishment gives optimum opportunity for the establishment of a large soil seed bank of French serradella. Scarified seed is sown in autumn once the chance of a false break has passed.
2. **Cover cropping using scarified seed** – this has been the main method of general pasture establishment traditionally used in NSW. A survey in 2009 of 300 farmers found 80% used this method to establish pasture but only 30% considered it a highly successful method. Cover cropping involves using a reduced rate of cereal in the final year of the crop rotation and sowing the scarified pasture seed with it. Such a system creates significant competition between the crop and the establishing pasture. The main reason this method of pasture establishment has been practised is as a means to partially offset the high cost of pasture establishment by being able to harvest some grain from the paddock.
3. **Twin sowing** – this method of pasture establishment was developed by Dr Angelo Loi and Dr Brad Nutt of the Department of Agriculture and Food Western Australia. It utilises the hard seed characteristics of Margurita and Erica to still offer farmers the ability to establish crop and pasture in a one pass sowing operation, but it is a method which completely removes competition between the crop and pasture.

   Twin sowing uses pods of Margurita or Erica which are very hard and require a significant period of time to soften and germinate in the soil. Pods are sown with cereal in the final year of crop. As the pods do not germinate (or only a few germinate in the first year), there is no need to reduce the crop sowing rate. The pods soften during the crop year and then emerge following rain the next autumn. Twin sowing allows farmers to get a full crop in the final year of the rotation and have pasture establish in the following year. The pasture is allowed to grow and set seed in the second year and following this, the paddock may be cropped again. This cycle can then continue.

   Twin sowing requires sowing of relatively high rates of in-pod seed. Experiments in NSW have so far used rates of 20-30kg pod/ha. French serradella is harvestable on farm using a conventional cereal header with the cost of seed pod production under this system being quite low. Sowing rates required for twin sowing are then reasonably economical if pod is produced in this way.

Care needs to be taken in twin sowing operations to ensure the pod is not buried too deeply. Pod should not be planted deeper than 10mm, otherwise significant losses can occur.

In NSW trials in these crop-pasture rotations, stand alone sowing has been most successfully established by sowing scarified French serradella seed as a stand alone pasture in year one and allowing it to set maximum quantity of seed. Cover cropping resulted in significant reduction in seed production of the legumes compared to the stand alone sowing. Previous research would suggest that for strong regenerating subterranean clover a seed yield in the first year of sowing of 150kg/ha would be required. In the year of the experiment shown, subterranean clover failed to set sufficient seed to meet this requirement either in the stand alone sowing or in the cover cropping treatment. By contrast, the French serradella produced quantities in excess or just below this amount at both locations (Figure 10).

Additionally seed size was also adversely affected under cover cropping in subterranean at both locations and in French serradella at one location (Figure 10). Seed size is directly related to seedling vigour. Therefore reduction in seed size in conjunction with low seed production in cover cropping systems is likely to impact on subsequent pasture productivity.

Pasture production in regenerating stands of French serradella established using stand alone sowing, cover cropping or twin sowing

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.

Regeneration from twin sowing using French serradella has been successful in the experiments undertaken so far compared to regeneration achieved from cover cropping (Figure 11). Winter production in particular has been very much more favourable using twin sowing compared to regeneration achieved from cover cropping or the production achieved from a late sown new stand.

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.

Effective use of biserrula in crop rotations

French serradella is a very prolific seed producer with approximately only half of the seed produced being germinable by the following autumn. This means there is capacity to use French serradella in self-sustaining crop pasture rotations.

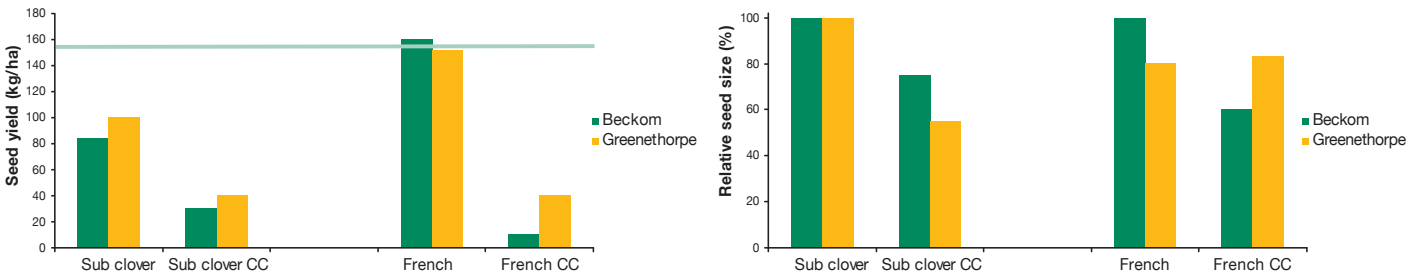

Figure 10. Seed production (kg/ha) and seed size (%) of subterranean clover (sub clover) and French serradella (French) at Beckom and Greenethorpe in NSW either as a stand alone sowing using scarified seed or using scarified seed sown under a cover crop (CC) of wheat where wheat sowing rate was 15kg/ha.

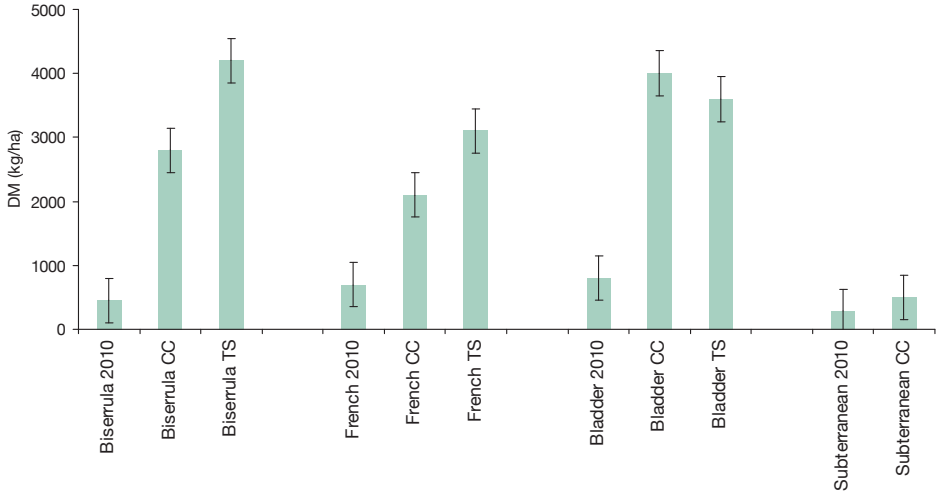

Figure 11. Winter 2010 herbage production (May to August) achieved from biserrula, French serradella, bladder clover and subterranean clover either from a May scarified seed sown in May 2010 or that achieved from regeneration of 2009 sowings established using covercropping (CC) or twin sowing (TS) at Greenethorpe, NSW.

Following first year seed set, only about half of the seed produced will be germinable by the next autumn. Therefore, it is possible to crop the paddock and still have sufficient viable seed to enable successful regeneration in the year following the crop (i.e. a 1:1 pasture-crop rotation). This type of strategy also effectively utilises the nitrogen fixed by the French serradella in the cropping phase.

Experiments have shown there is still sufficient seed carryover following a crop for successful regeneration and herbage production (Figure 12).

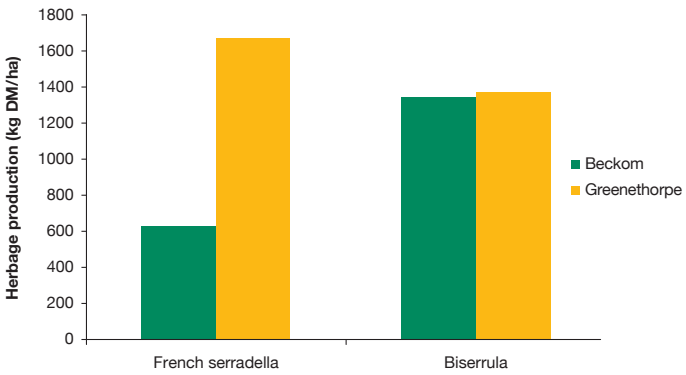

Figure 12. Herbage production in winter 2011 of Margurita French serradella and Casbah biserrula at Beckom and Greenethorpe. These were plots sown as stand alone scarified sowings in 2009, then cropped in 2010 and regenerating in 2011. Note that plots received no fertiliser in 2011.

Only the hardseeded French serradella varieties, Erica and Margurita, should be used in self-sustaining crop-pasture rotations and the cropping phase should not be longer than one year, otherwise it is likely there will be insufficient seed reserves for successful regeneration. The soft seeded varieties of French serradella should not be used in self-sustaining crop-pasture rotations as they do not have sufficient hard seed to withstand the crop year. The soft seeded varieties, however, are suitable for use as break crops.

Research in NSW has shown that wheat sown following a French 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 13). This would suggest that in addition to providing high quality pasture for livestock in the pasture phase, use of legumes such as French serradella could significantly reduce expenditure on nitrogen by farmers in the cropping phase.

Using French serradella in pasture systems

French serradella can be incorporated successfully into longer term pasture systems either with other legume and grass species. As with other annual pasture legumes, French serradella requires light and soil contact to successfully regenerate year in-year out. To achieve this, pastures containing French serradella and other annual legumes should be grazed in summer and autumn to remove excessive litter burdens.

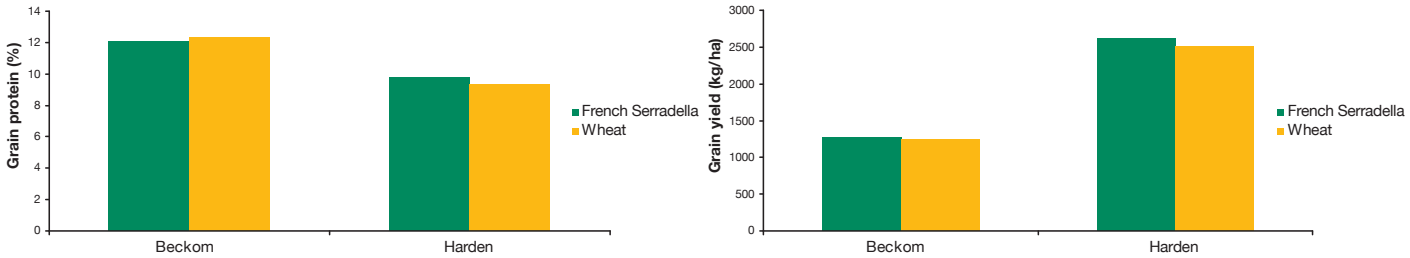

Figure 13. Grain protein (%) and yield of grain (kg/ha) of wheat sown after French serradella with no nitrogen fertiliser or wheat sown following wheat with nitrogen fertiliser (DAP at 120kg/ha).

Benefits of French serradella in farming systems

French serradella in NSW has proved to be a very efficient plant, particularly in drier than average years. The root system of French serradella establishes quickly. This means that if out-of-season rainfall is received in summer, French serradella has a better chance of surviving compared to traditional legumes such as subterranean clover. Similarly, if rainfall in spring is low or highly variable, French serradella is better able to continue growing and set seed than traditional shallow rooted annual legumes (Figure 14). The ability to set seed, especially in adverse climatic conditions mean that longer term persistence is improved.

Figure 14. French serradella and subterranean clover during a dry spring period. Note the subterranean clover has died off while the French serradella is still green and actively growing. (Photo: Angelo Loi, Department of Agriculture and Food, Western Australia).

The higher hard seed varieties of French serradella, Erica and Margurita, also lend themselves to setting up more flexible crop-pasture rotations. Traditionally in NSW a phase crop-pasture system has been used which is quite inflexible. The hard seeded French serradella varieties offer farmers the opportunity, to create more flexible crop-pasture rotation systems by establishing some areas of the farm as 1:1 rotations, while other areas may remain as traditional phase rotation areas or alternatively utilise other species such as biserrula to have self-sustaining crop-pasture rotation systems that allow longer cropping phases. Incorporation of new hardseeded legumes with varying hard seed levels on different areas of the farm in crop pasture rotations may allow farmers to more quickly alter the crop to pasture ratio of the farm and therefore the crop to livestock ratio of their farm compared to traditional phase farming systems.

Establishing and managing French serradella

Selecting and preparing the site

As with the establishment of any new pasture, the area to be sown to French serradella 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.

Sowing requirements and sowing rates

French serradella 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. French serradella can be sown either into a conventional seed bed or can be direct drilled. It is not recommended that French serradella 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.

There are two ways to sow French serradella

1. **Scarified seed** – this is seed that has been extracted from the pod segments. This seed will be virtually all germinable at sowing. If establishing a French serradella based pasture using this type of seed, then it is best to sow without a cover crop. Cover cropping creates significant competition between the crop and pasture for light and moisture which can result in significant reduction in seed set and the size of the seed produced. The main goal of the establishment year is to create as large a seed bank as possible so that there is sufficient seed available for strong regeneration in following years.

   If sowing French serradella alone, then rates of 7-10 kg/ha of scarified seed should be used. If French serradella is to be part of a mixture with other legumes or with grasses then 2-6kg/ha scarified French serradella seed should be used depending on what the companion species are.

2. **In-pod seed** – when French serradella is harvested, the seed pod segments into individual pod fragments which contain a seed. This pod can be sown directly. Pod of soft seeded varieties will germinate once sufficient moisture is received after sowing. For the higher hard seed varieties, Erica and Margurita, the rate of breakdown and germination of the pod will be much slower.

   Soft seed varieties should be sown at rates of 15-30kg pod/ha to achieve a thick stand of French serradella. The rate can be reduced if other legume species are to be sown in the mix.

   Hardseeded varieties require the same type of sowing rate (15-30kg pod/ha). If sowing in late autumn, rates at the higher end of the range would be necessary to achieve sufficient germination. The hardseeded varieties, Erica and Margurita, lend themselves to sowing in-pod as part of a twin sowing operation (refer page 12) as this allows sufficient time for the pod to break down under the final year of the crop and emerge in the following autumn. Additionally, there is also capacity to sow pod of hardseeded varieties in summer and use the summer period to break down hard seed.

Fertiliser requirements

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

French serradella requires a different type of rhizobium (Group S) to subterranean clover (Group C). The rhizobium required by French serradella is the same as that required by lupins.

Traditionally, peat-based slurry inoculums have been used. This type of 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 15).

Figure 15. Effectively nodulated French serradella on the left of the photo, poorly nodulated French serradella on the right. Note the dark green foliage and density of the well nodulated serradella compared to the yellowish, low density area of the paddock (Photo: Belinda Hackney, NSW DPI).

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 that are effectively fixing nitrogen will be pale to deep pink in colour when cut open (Figure 16). 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.

Figure 16. An effectively nodulated legume root system. Note the pink colour of the nodules.

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.

No herbicides are registered specifically for use on French serradella. In mixed pasture systems containing French serradella, Broadstrike generally causes minimal damage, while Raptor and bromoxynil also appear relatively safe. Spinnaker appears useful as a pre-emergent weed control.

Selective grass herbicides can be used to remove grass weeds from French serradella.

Some farmers in NSW and WA have been using blanket wipers successfully to control weeds in French serradella pastures. Blanket wipers allow differences in height of French serradella and target weeds to be exploited to control weeds (Figure 17).

Figure 17. A blanket wiper may be a useful strategy for controlling weeds in French serradella by exploiting height differences between the biserrula and target weed. This model has a very abrasive wiping surface resulting in effective target weed coverage. It also has constant pressure delivery system to the wiping mats which ensures effective delivery.

Controlling pests

Red-legged earth mite can cause significant damage to French serradella 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, French serradella has good tolerance of RLEM. French serradella has moderate tolerance of blue-green aphids and cow pea aphids. It is moderately susceptible to lucerne flea. French serradella is very susceptible to attack by native budworm and infestation of this pest can severely affect seed production.

Management for regeneration

Whether or not French serradella is grazed in the establishment year will depend largely on sowing time and growing conditions. Essentially, treat French serradella 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 French serradella 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.

Once a French serradella stand is established it will tolerate moderate to high grazing pressure well.

Seed production and harvest

French serradella is an aerial seeder as opposed to subterranean clover which buries a high proportion of burrs. French serradella is easily harvested using a conventional header (Figure 18) with up to 700kg pod/ha harvested in some cases by NSW farmers in recent years.

Figure 18. French serradella being harvested with a conventional header (Photo: Angelo Loi, Department of Agriculture and Food, Western Australia).

French serradella and animal production

How does animal production from French serradella compare to other legumes?

As yet in NSW, the area sown to French serradella is quite small and actual livestock production figures on French serradella pasture is limited. Feed test results show French serradella 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 French serradella is similar to subterranean clover on a basis of kilograms of forage fed. However, given the capacity of French serradella to produce higher quality forage under adverse seasonal conditions, the actual animal product produced be hectare is potentially higher (Figure 19).

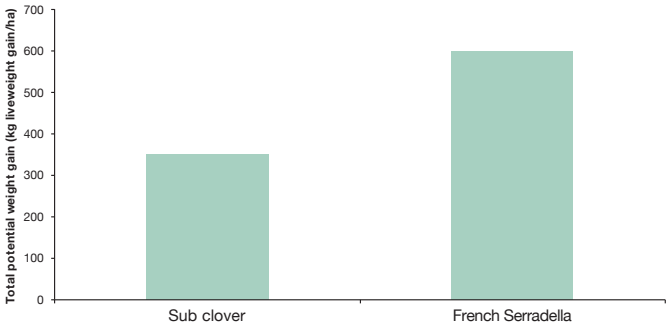

Figure 19. Potential liveweight gain (kg liveweight/ha) for herbage grown in below average rainfall year (2008) at Harden NSW.

Sequential sampling through the spring period showed that metabolisable energy, protein and digestibility levels were similar in French serradella and subterranean clover throughout the season. However, the herbage production of French serradella throughout the mid and late spring period was significantly higher than for subterranean clover. Thus, overall potential animal production, due to higher herbage production, was considerably higher in this period compared to subterranean clover (Figure 20).

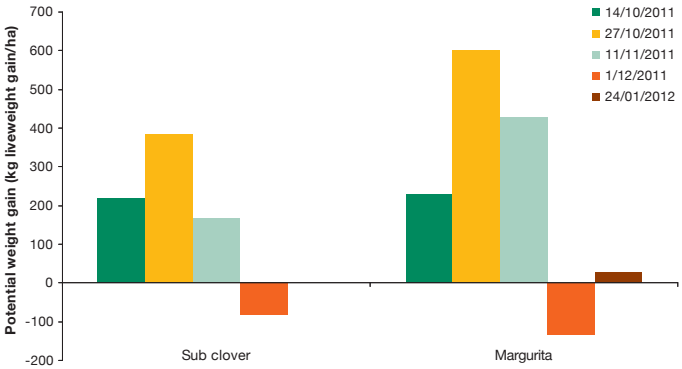

Figure 20. Potential liveweight gain per hectare from subterranean clover and French serradella (Margurita) on five possible occasions in spring-summer 2011/12 at Harden, NSW, based on yield and feed quality at that harvest date. Data modelled in Grazfeed. Note there was insufficient plant material remaining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

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

French serradella 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 the higher hard seed French serradella varieties, Erica and Margurita are compared. At this site in southern NSW, false breaks which killed subterranean clover plants were experienced in the second and third year resulting in very poor third year productivity. By contrast, the French serradella 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.

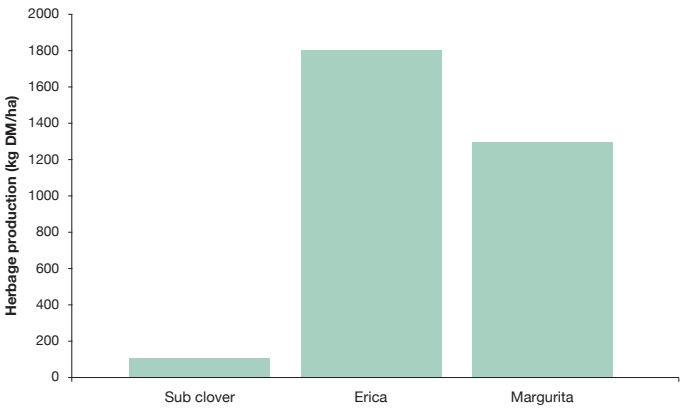

Figure 21. Third year herbage production of sub clover and Erica and Margurita French serradella where false breaks resulting in death of sub clover plants occurred in year two and year three. Note Dalkeith sub clover used.

French serradella has a rapidly developing root system and plants which if germinated on summer-early autumn rainfall have good capacity to survive until late autumn rain is received. This adaptation means that French serradella 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 French serradella may enable higher levels of animal production to be achieved at this time of year.

The more extensive root system of French serradella 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, French serradella can remain green until late December and even into late January-February in higher rainfall areas.

Farmer case studies

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

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 French serradella?: Seed of French serradella was originally purchased to sow in 2006, however seasonal conditions were very poor. Seed was sown in 2009, which was again a very dry year. French serradella performed very well in 2009 despite really low rainfall and produced about 1000kg DM/ha. Sub clover didn't even come close to setting seed in that year. Regeneration in that area was very good in the second year with about 4 t DM/ha (Figure 22).

In-pod French serradella has also been sown as a twin-sowing operation and results there have also been very promising (Figure 23).

French serradella is very readily accepted by the sheep and they do well on it. French serradella could be a useful complement to cropping rotation in paddocks on the farm, especially in mixes with annual legumes with similar hard seed levels and suited to similar 1:1 rotations. It would work well with species such as bladder clover and gland clover in this role.

Any problems?: French serradella is quite sensitive to many broadleaf weed herbicides. MCPA in particular is a valuable tool on this farm in a spray-graze role to clean up weeds. French serradella doesn't tolerate MCPA. However, at least some of the problem broadleaf weeds can be controlled with the blanket wiper which has been built for this purpose and also for use in other crops on the farm.

So far there hasn't been much success in trying to harvest French serradella seed on farm. In both years when this could have been done, late unseasonal heavy rain has flattened the crop. These crops have been quite tall and it might be that they need to be grazed a bit harder prior to shutting up for seed production so that they are less likely to lodge. It is hoped that some can be harvested in the near future?

Figure 22. Photo on left shows French serradella in foreground at Mike and Velia O'Hare's Beckom property in October 2009. Photo on right shows the same paddock which had regenerated from 2009 seed set in October 2010. (Photos: Belinda Hackney, NSW DPI).

How do you think you will use French serradella in the future?: I think French serradella could be really useful in crop-pasture rotations on the farm. Certainly it is very palatable to livestock and it has proved its ability to survive and produce in tough years.

Figure 23. Farmers inspecting a Margurita French serradella paddock established at Mike and Velia O'Hare's Beckom NSW property using twin sowing. French serradella seed pod was twin sown in 2010 and regeneration is shown in spring 2011.

Farmer name: David and Kim Lee
Location: Barmedman, NSW
Long term average rainfall: 425mm
Farming enterprises: Winter crop and sheep
Variety sown: Margurita

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. We needed an alternative legume to fill the role of providing nitrogen for crops and quality feed for sheep. French serradella was first sown in 2009 in a very poor year. The French serradella did very well that year producing around 1800kg DM/ha and setting a good amount of seed (Figure 24). By comparison, the surrounding pasture paddocks produced less than 500kg DM/ha and any legume in those paddocks didn't set seed.

Why French serradella?: Both French serradella and biserrula were sown in the first year (2008) and both did very well. I think both have a role on the farm. French serradella for shorter rotations and biserrula for areas where a longer cropping phase might be used. French serradella should combine well with other annual legumes with similar hard seed levels such as bladder clover and gland clover. French serradella seems to be well accepted by sheep and the quality of it from lab analysis indicates it should support high levels of animal production. Its ability to provide feed in tough seasons is really impressive.

Any problems?: It does take a bit more planning in terms of weed control with French serradella and other new legumes as they aren't as tolerant of a lot of herbicides as sub clover, however they make up for that in productivity. The lower herbicide tolerance is not necessarily a bad thing – it makes you more aware of reducing weed burdens in the crop phase. I think the weed wiper has a real place in future weed control – not just for these legumes, but for crop and pasture weed management in general.

How do you plan to use French serradella in the future?: French serradella will have a good fit on the farm in crop-pasture rotations. Nitrogen fertiliser costs are so variable and just generally getting higher over time, so the self-sustaining crop-pasture rotation really has a big fit for future cropping systems and the amount of feed these new legumes can provide in the pasture year for livestock is just another advantage.

Figure 24. David Lee and Dr Angelo Loi (Department of Agriculture and Food Western Australia) in a Margurita French serradella pasture on David's property near Barmedman in spring 2008. Note the volunteer paddock in the background which produced less than 500kg DM/ha in spring compared to 1.8 t DM/ha in the French serradella.

Farmer name: Phil Salter
Location: Manildra, NSW
Long term average rainfall: 650mm
Farming enterprises: Sheep, winter crop
Variety sown: Margurita

Reasons for move to new legumes: Most of our long term pastures are based on perennial grasses with an annual legume component – traditionally sub clover. Sub clover has generally performed well in good years, but during the drought years, its production was unreliable and it didn't reliably set seed. Some of the new legumes were worth looking at as they had deeper root systems and were acid soil tolerant. Some of the soils in this are very acidic with high levels of aluminium and they can dry out quickly.

A large proportion of the property is also in a crop rotation – a legume that can survive a crop and regenerate without needing resowing, or one that can be sown as a break crop is potentially very valuable to reduce nitrogen costs and improve grazing quality in crop years.

Why French serradella?: French serradella was just one of several species sown on various parts of the property. Others included arrowleaf clover, balansa clover and gland clover. Due to its acid soil tolerance and ability to grow well on light textured soils, French serradella was sown on some of the lighter country. It has persisted well in this area as a component of the pasture.

Any problems?: In the first year, the French serradella had a set back due to an aerial spray over with a broadleaf weed herbicide that it is not tolerant to. However, it recovered and set seed and has persisted since. The lack of broadleaf weed herbicide options is a bit of a concern.

How do you plan to use French serradella in the future?: It has a definite role in longer term pasture mixes, especially on the poorer quality soils and it is another tool that can be used in crop rotations, particularly as an alternative to lupins – this might be as an opportunistic break crop or as part of a planned area of continual 1:1 rotations with the harder seeded varieties.

Farmer name: David and Julie Brien
Location: Greenethorpe, NSW
Long term average rainfall: 600mm
Farming enterprises: Sheep, winter crops
Variety sown: Margurita

Reasons for move to new legumes: The pastures, both permanent and those in the cropping rotation had traditionally been based on subterranean clover. David and Julie's father had been a sub clover seed producer in the past as well. The sub clover base of the pasture system was failing and as a result there was increased reliance on fertiliser nitrogen for the crops as well as pasture growth (both permanent and those in the cropping rotation) not being as productive as they should have been. Sub clover was badly knocked around by short springs and there were also large losses of seedlings in false breaks. The new legumes with higher hard seed levels and deeper root systems appeared to have potential to alleviate issues around false breaks and seed set. First French serradella was sown in 2010 (Figure 25).

Why French serradella?: The hard seed levels of French serradella were complementary to the crop rotation being run on the farm, plus it offered additional flexibility. Lupins have been used in the crop rotation, but returns and productivity from them are not reliable. French serradella fits this role – either the soft seeded varieties as a one year break crop or the harder seeded varieties as part of a self sustaining crop-pasture rotation. The ability to harvest seed for use on farm is also attractive as is the potential to use this in-pod seed of the hardseeded varieties for twin sowing operations. The higher hard seed varieties also suit the longer term pastures well. French serradella has been well accepted by sheep.

Any problems?: So far it has done well. Harvested pod off the seed production block in 2010 and used it in a twin sow with canola in 2011.

How do you plan to use French serradella in the future?: Continued use in crop-pasture rotations.

Figure 25. David and Julie Brien, Greenethorpe, NSW pictured in a seed block of Margurita French serradella which yielded approximately 650kg pod/ha.

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