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Improving subtropical grass pastures on the south coast of Western Australia

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Bulletin 4892

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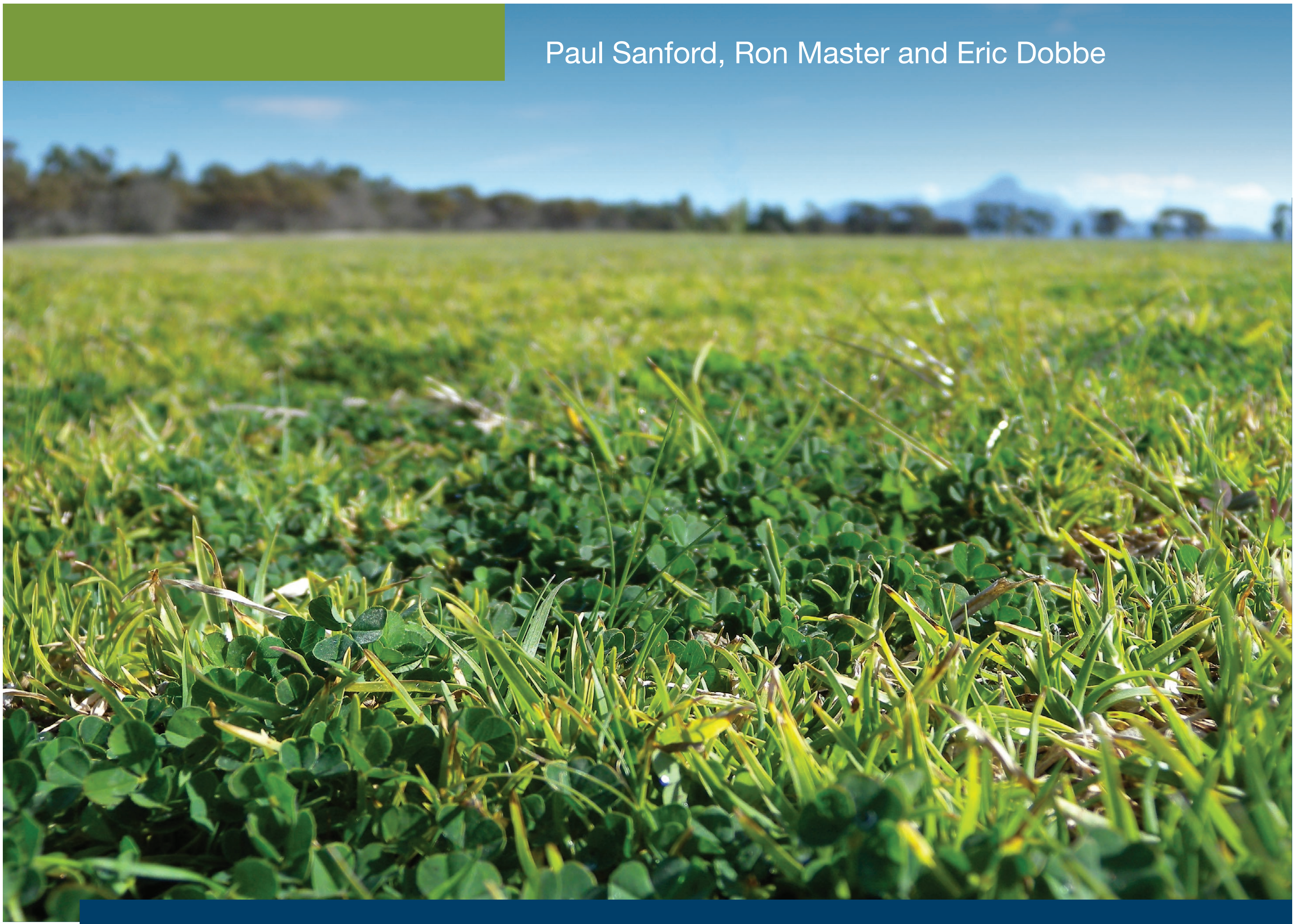
Improving subtropical grass pastures on the south coast of Western Australia

Paul Sanford, Ron Master and Eric Dobbe



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Contents

Introduction

Subtropical perennial grasses make a valuable contribution to forage production across the south coast of Western Australia (WA) and have proven to be particularly useful at filling the summer/autumn feed gap, resulting in increased stocking rates and a reduction in supplementary feed. They also reduce soil erosion and use more water, helping to reduce deep drainage to groundwater and salinity.

Kikuyu has been the most successful subtropical grass to date with over 150 000 hectares (ha) established on the south coast. Research has also found that panic grass has a lot of potential in this environment. The area sown to kikuyu is expected to continue to grow and it is likely that panic grass will expand to the point that it is considered a mainstream perennial species.

As kikuyu has been adopted in a wide range of environments and in different farming systems, a number of management challenges have become evident. Foremost among these are improving the annual legume content and increasing production.

Kikuyu is normally grown in conjunction with a temperate legume to provide nitrogen for biomass yield and feed quality during the cooler months. Many kikuyu pastures are either consistently low in legume density or experience poor legume content in some seasons, so there is considerable potential to increase both winter and spring yield of subtropical pastures via annual legumes.

Kikuyu and subterranean clover growing together (left). Root nodules of subterranean clover (right) improve soil nitrogen fertility in subtropical grass pastures

This bulletin reports on the findings of a research project funded by DPIRD and MLA that investigated methods to improve legume content and increase production of both kikuyu- and panic-based pastures on the south coast of WA.

For more information on subtropical grass pastures, refer to the following publications and websites:

- **Moore, GA, Sanford, P & Wiley, T 2006, 'Perennial pastures for Western Australia', *Bulletin 4690*, Department of Primary Industries and Regional Development Western Australia, Perth, viewed 1 August 2017**
  http://researchlibrary.agric.wa.gov.au/bulletins/1/
- **Moore, GA, Yates, R, Barrett-Lennard, P, Nichols, P, Wintle, B, Titterington, J & Loo, C 2013, 'Establishment guide for sub-tropical grasses: key steps to success', *Bulletin 4840*, Department of Primary Industries and Regional Development Western Australia, Perth, viewed 1 August 2017**
  http://researchlibrary.agric.wa.gov.au/bulletins/34/
- **EverGraze n.d., South coast WA, viewed 1 August 2017**
  http://www.evergraze.com.au/south-coast-wa/

Subterranean clover growing among kikuyu grass

1. The value of improving subtropical grass pastures

Key messages

- Increasing the legume content of kikuyu pasture improves gross margins (GMs).
- Kikuyu pasture with a high clover content returns better GMs than an annual-based pasture.
- To realise higher GMs, producers need to increase stocking rates to use a substantial amount of the extra feed that is grown.
- Lifting legume content of kikuyu pastures increases GMs by an average $40/ha.
- Sowing annual ryegrass into kikuyu pastures will also improve GMs.

All pasture improvements require varying investments in money and time. It is therefore essential to quantify the value of any improvement to subtropical pastures so the producer can decide where to direct resources.

The analysis presented in this section examines how GMs vary in response to changes in subterranean clover content in kikuyu-based pastures in three different locations across the south coast—Wellstead (long-term average rainfall 468 millimetres), Mt Barker (long-term average rainfall 643mm) and Esperance (long-term average rainfall 587mm). The model simulated sheep farms running a dual-purpose merino enterprise, where 75% of the feedbase was subterranean clover/annual ryegrass/capeweed and the remaining 25% of the feedbase consisted of either:

- kikuyu pasture with no subterranean clover
- kikuyu pasture with low subterranean clover content (~25%)
- kikuyu pasture with medium clover content (~50%)
- kikuyu pasture with high clover content (~75%)
- no kikuyu—100% subterranean clover/annual ryegrass/capeweed.

The average GM figures for the whole farm at Wellstead are presented in Figure 1. Two things are apparent from the analysis: first, kikuyu pasture with high clover content return higher GMs than an annual pasture-based system, and second, to realise those higher GMs, you need to run stocking rates that use a substantial amount of the feed that is grown.

At realistic stocking rates (6.5–9.1 ewes/ha), going from no clover to high clover content increased GMs by between $74 and $167/ha. Even a shift from low clover content to high clover content will potentially increase GMs by between $67 and $148/ha, depending on stocking rate.

Improving subtropical grass pastures will support higher lamb turnoff

At medium stocking rates (e.g. 7.8 ewes/ha) lifting clover content from one category to the next increases GMs by about $40/ha on average.

The analysis also illustrates the principle that along with improving a pasture you should also increase stocking rates to maximise the return on your investment. For example, for an enterprise running 6.5 ewes/ha, increasing clover content in kikuyu pasture from low to high alone would increase GMs by $67/ha (from $400 to $467/ha). However, if the improvement in clover density were to be combined with an increase in stocking rate (from 6.5 to 7.8 ewes/ha), GMs would improve by $111/ha (from $400 to $511/ha).

What accounts for the increase in GMs with improved clover content? As subterranean clover content increases in kikuyu pasture, GMs are higher because clover drives more pasture of better quality, leading to a reduced need for supplementary feed, a modest increase in meat turnoff and an opportunity to increase stocking rates.

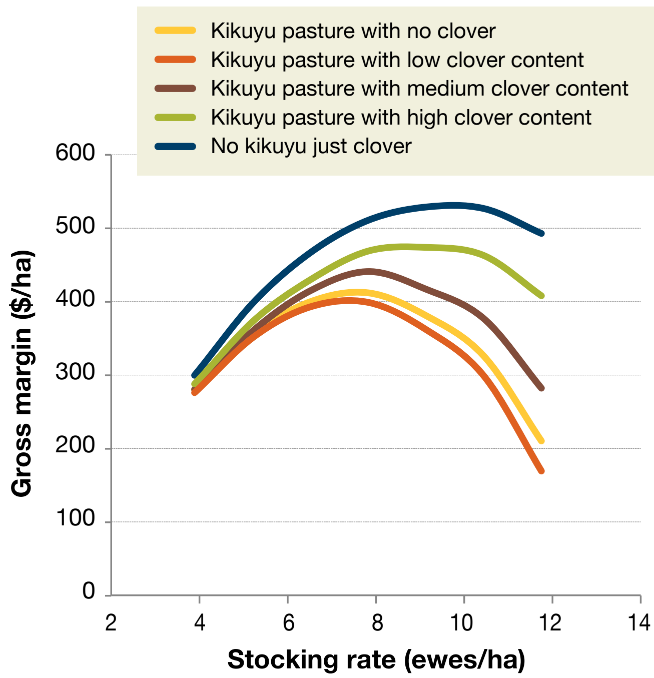

Figure 1. Simulated GMs ($/ha) for a dual-purpose sheep enterprise in Wellstead in which 25% of the feedbase consists of kikuyu pastures with varying amounts of subterranean clover. (Simulation run using climate data from 1975 to 2015 at 3.9, 5.2, 6.5, 7.8, 9.1, 10.4 and 11.7 ewes/ha)

To gain some understanding of how the climate across the south coast might influence the response in GMs to varying subterranean clover content, we simulated the same farming system in Mt Barker and Esperance (see Figures 2 and 3 respectively). As in Wellstead, increasing the clover content in both Mt Barker and Esperance lifted GMs. Realistic stocking rates (7.8–10.4 ewes/ha) are higher compared to Wellstead because of more rainfall and higher pasture productivity. At these stocking rates, the average increase in GM at Mt Barker and Esperance was $36 (range $7–94) and $42/ha (range –$13–$111) respectively.

In calculating the GMs presented in this section, all costs (see Appendix 1) were accounted for, except the cost of implementing the tactics to increase legume content. While the cost of such tactics will vary considerably and each producer needs to do their own cost–benefit analysis, the following examples provide a guide.

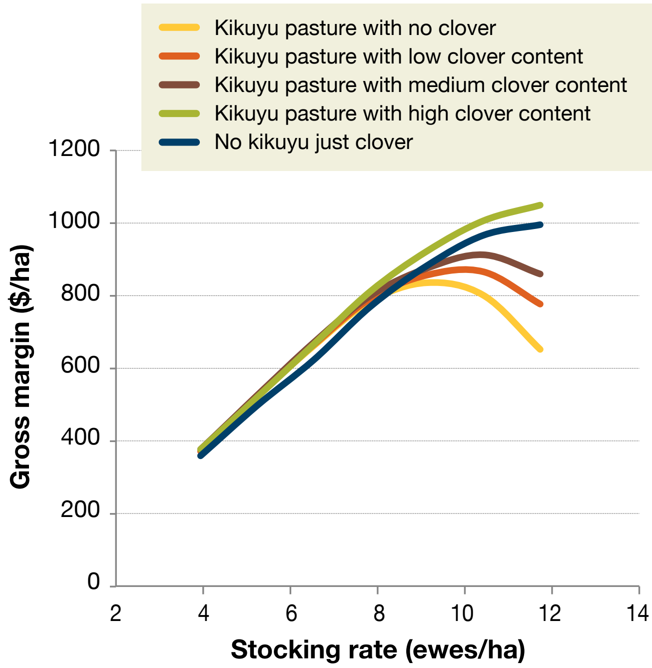

Figure 2. Simulated GMs ($/ha) for a dual-purpose sheep enterprise in Mt Barker, where 25% of the feedbase consists of kikuyu pastures with varying amounts of subterranean clover. (Simulation run from 1975 to 2015 at 3.9, 5.2, 6.5, 7.8, 9.1, 10.4 and 11.7 ewes/ha

Highly productive subtropical grass pastures reduce reliance on supplementary feed

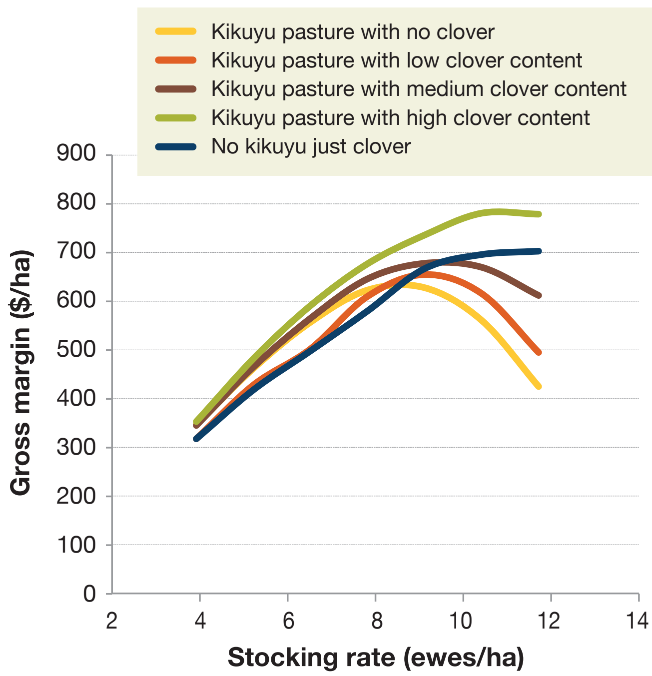

Figure 3. Simulated GMs ($/ha) for a dual-purpose sheep enterprise in Esperance, where 25% of the feedbase consists of kikuyu pastures with varying amounts of subterranean clover. (Simulation run from 1975 to 2015 at 3.9, 5.2, 6.5, 7.8, 9.1, 10.4 and 11.7 ewes/ha)

Scenario 1: increasing clover content in kikuyu using a grass-selective herbicide

Insufficient rainfall in autumn has led to low clover content in kikuyu pastures in Wellstead. To prevent the kikuyu from causing moisture stress in clover seedlings, one producer sprays some paddocks with the grass-selective chemical, clethodim, at 1 litre (L)/ha and insecticide to control RLEM. Clethodim is $15/L (i.e. $15/ha), insecticide $3/ha and on-farm spray rig running costs are about $15/ha. The total cost is $33/ha.

Based on the simulated GMs presented in Figure 1 and using a stocking rate of 6.5 ewes/ha, if the spray treatment resulted in kikuyu paddocks with medium clover content, the cost–benefit ratio would be 1.8:1 for that season, resulting in a profit of $22.50/ha. If the spray treatment resulted in high clover content, the cost–benefit ratio would be 8:1 with a profit of $180/ha. Note that it is likely the benefit will carry over to following seasons in the form of increased legume content.

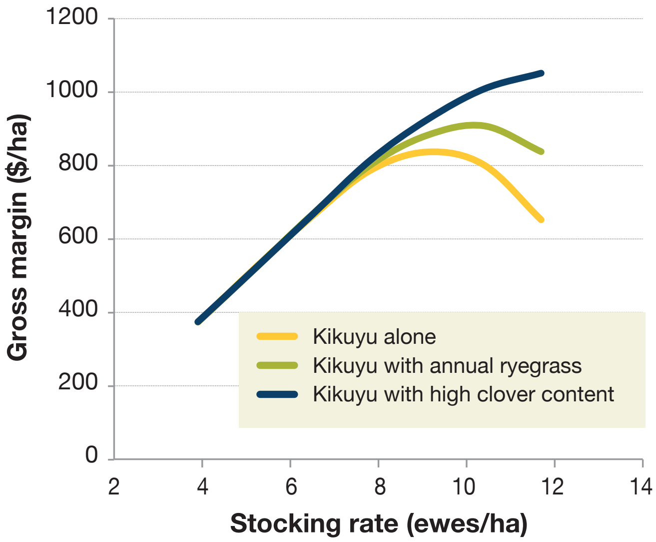

Figure 4. Simulated GMs ($/ha) for a dual-purpose sheep enterprise in Mt Barker, where 25% of the feedbase consists of kikuyu pastures comprising either kikuyu alone, kikuyu with annual ryegrass, or kikuyu with subterranean clover. (Simulation run from 1975 to 2015 at 3.9, 5.2, 6.5, 7.8, 9.1, 10.4 and 11.7 ewes/ha)

Scenario 2: increasing clover content in kikuyu by sowing in autumn

For the past few years, a producer in Mt Barker has had very little clover in the kikuyu pastures on the property. To renovate the paddocks, they are sprayed with a grass-selective chemical (clethodim) at 1L/ha after the break of season and sown to subterranean clover at 10 kilograms (kg)/ha. Clethodim is $15/L (i.e. $15/ha) and the on-farm spray rig running costs are about $15/ha. Subterranean clover seed costs ~$70/ha, inoculant $1/ha, insecticide $3/ha and contract sowing $45/ha. The total cost is $149/ha.

Using the GMs presented in Figure 2 at a stocking rate of 7.8 ewes/ha and a resulting pasture with medium clover content, the cost–benefit ratio would be 0.21:1 and it would take around five years to break even, assuming the clover regenerated for many following seasons. If once the subterranean clover was established, the producer also increased the stocking rate from 7.8 to 9.1 ewes/ha, the cost–benefit ratio would improve to 2.3:1, highlighting the value of increasing stocking rate to capitalise on pasture renovation.

An alternative method of enhancing the performance of kikuyu pastures is to sow annual ryegrass or forage oats to provide feed in winter/early spring. Producers typically use ryegrass and drill the seed (20–40kg/ha) in autumn after the break of season, either with or without suppressing the kikuyu. This tactic is most successful in higher rainfall environments (>600 millimetres) on soils with a pH ($CaCl_2$) of 5.0 or higher.

The simulation model was used to compare the value of annual ryegrass in kikuyu pasture to that of a kikuyu/subterranean clover mix at Mt Barker. The results are presented in Figure 4. The addition of annual ryegrass also increases GMs but not to the same extent. At a stocking rate of 9.1 ewes/ha, kikuyu grown alone returns a GM of $836/ha. With annual ryegrass, the GM increases by $45/ha to $881/ha and with subterranean clover at high legume content by $87/ha to $923/ha. This tactic is used effectively by a number of cattle growers in the Albany region, allowing them to increase stocking rates or reduce their reliance on supplementary feed.

Scenario 3: sowing annual ryegrass into kikuyu to improve winter feed

A producer in Mt Barker has had a winter feed gap for the past few years and decides to drill annual ryegrass into the property's kikuyu stands. Paddocks are sown after the break of season at 20kg/ha of annual ryegrass. Seed costs are $60/ha, insecticide $3/ha and contract sowing $45/ha. The total cost is $108/ha.

Using the GMs presented in Figure 4 at a stocking rate of 9.1 ewes/ha and going from a sward containing only kikuyu to one with ryegrass, the cost–benefit ratio would be 1.7:1. While this is an attractive cost–benefit ratio, be aware that, unlike clover, ryegrass would need to be sown every few years and the system requires inputs of nitrogen fertiliser (cost not included) to remain productive in the long term, unless a legume is introduced.

The economic analyses presented make a compelling case for improving subtropical grass pastures by increasing legume content or introducing desirable winter-active species such as annual ryegrass. In our experience, the results are in broad agreement with the experiences of livestock producers who run kikuyu pastures on the south coast. We are therefore confident that the tactics covered in this publication will benefit all producers who are growing or who intend to grow subtropical grasses.

Beef production on kikuyu-based pastures

Kikuyu has been proven to lift profit for both wool and prime lamb enterprises

2. Improving legume content

Key messages

- Kikuyu pastures can frequently experience poor legume content.
- Subterranean clover density can be increased in kikuyu pastures by applying sufficient grazing pressure before break of season, given sufficient soil moisture, insect control and space for clover seedlings.
- Legume content can be increased after the break of season using a grass-selective chemical (e.g. 0.5–1L/ha clethodim) to supress the subtropical grass. This tactic requires an adequate legume seedbank.
- If it is necessary to sow a legume because of a poor seedbank, suppress kikuyu and drill in the seed. Do not broadcast.
- Subterranean clover remains the best companion legume for kikuyu.
- Serradella is a good option for deep sands and can be sown as pod in summer or seed in winter.

Most subtropical grass pastures on the south coast of WA are kikuyu-based pastures that have a subterranean clover seedbank. Yet many of these pastures frequently experience poor legume content because kikuyu out-competes the emerging clover seedlings, causing many to die. This competition is mostly for soil moisture, which is why legume content tends to be lower in drier years as more seedlings die due to a kikuyu-induced drought. Other factors that lead to poor clover establishment include soil acidity (see '*Addressing soil constraints*', page 22), predation by redlegged earth mite (RLEM), and an excess of standing kikuyu biomass that prevents light and moisture reaching the soil surface.

There are proven methods that can be used to improve legume content (and hence improve feed and increase nitrogen) in kikuyu pastures. Foremost among these is grazing. Heavily grazing kikuyu pastures in the autumn before the break of season to a residual biomass of about 800–1000kg dry matter (DM)/ha opens up the sward, allowing moisture and light to reach the ground and space in which the emerging clover seedling can develop. RLEM control is also crucial to prevent seedling losses through predation.

Subterranean clover remains the best companion legume for kikuyu

Suppressing kikuyu with a grass-selective herbicide

While these approaches work well, there are situations where the producer is unable to manage kikuyu competition with these tactics, leading to a kikuyu-dominant pasture for much or all of the growing season. Examples include having insufficient sheep to manage the area under kikuyu in the lead-up to the break of season or pastures grazed by cattle at modest stocking rates.

The following section outlines an alternative technique for reducing kikuyu competitiveness using herbicides. If you have an adequate legume seedbank, this is a cost-effective method to improve legume content

Suppression after the break of season

Suppressing kikuyu with glyphosate in autumn before the season break will lead to an increase in legume content within the growing season. However, this approach is counterintuitive in a permanent pasture, as it results in the loss of valuable out-of-season feed. The use of a grass-selective herbicide following the break allows the producer to fully use the kikuyu out of season, assess whether it is likely to be a poor or good clover season, and then apply appropriate management.

Recent research examining the relationship between the rate of application of the grass-selective chemical, clethodim, and percentage kikuyu ground cover (Figure 5) has demonstrated that rates between 0.5 and 1L/ha substantially suppress kikuyu in autumn. However, Figure 5 also shows that the degree to which kikuyu ground cover is diminished at the same rate of clethodim varies from season to season. In the case of the trial data, all of the treatments had returned to around 100% kikuyu ground cover by the following year, although this is not always the case. At another site in Denbarker, recovery took longer.

Kikuyu not only competes with subterranean clover but with all the plant species that make up the sward, including weeds. The extent of this competition becomes apparent when you suppress kikuyu. Weeds such as silver grass, capeweed and chickweed can go from being low in plant numbers to high very quickly. When considering suppressing kikuyu, be mindful of the weeds that are present and either control them beforehand or have a plan to control them following suppression (see '*Controlling weeds*', page 26).

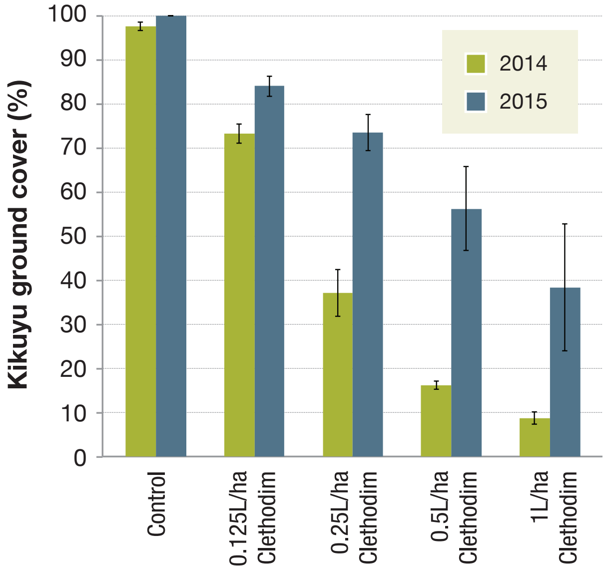

Figure 5. Relationship between percentage kikuyu ground cover and various rates of clethodim (L/ha) applied in autumn in 2014 and 2015 to a kikuyu-based pasture in Albany. (Measurements taken in July 2014 and June 2015; error bars represent standard error of the mean)

Only one trial has been conducted examining the degree to which clethodim can suppress panic grass. The findings (albeit preliminary) indicate that panic is perhaps more tolerant of clethodim than kikuyu and that about 1L/ha in autumn is required to provide adequate suppression.

The next two sections detail how the chemical suppression of subtropical grasses can be employed to increase the legume content of pastures with or without a good legume seedbank.

Pasture with a good legume seedbank

The majority of kikuyu-based pastures have an adequate subterranean clover seedbank yet in some seasons many of these pastures experience poor legume content. Research with clethodim has confirmed that use of this grass-selective herbicide following the break of season can increase legume content (e.g. Figure 6).

In Wellstead (data not presented), the use of clethodim led to an increase of 460kg DM/ha (30%) of subterranean clover for the winter period. The clethodim reduced the biomass of silver grass, most likely because it was still at an early seedling stage (1- to 2-leaf stage), while flatweed biomass increased.

In Esperance, we achieved similar results in terms of the changes in botanical composition but the response to clethodim was larger — a 26% increase in legume content made up of both subterranean clover and yellow serradella (Figure 6). Silver grass decreased but Guildford grass and a range of other weeds increased in response to the reduced competition from kikuyu.

Effect of various rates of clethodim in autumn on kikuyu. From left: 125, 250, 500 and 1000 millilitres (ml)/ha

Given that clethodim is cheap the benefits of an increase in legume content, it is clear this option provides a good economic return when legume content is below that required to support adequate livestock production through winter and spring.

Pasture with a poor legume seedbank

A lesser number of kikuyu pastures have a poor legume seedbank and these require grass suppression and sowing seed to increase legume content. Note that only subterranean clover, yellow serradella and French serradella are proven and commonly sown companions. Information on the general characteristics of suitable annual legumes is given in Appendix 2.

Impact of suppression with clethodim on a dense kikuyu pasture that has a substantial subterranean clover seedbank. (Nil suppression on the left plus suppression on the right with 0.5L/ha of clethodim)

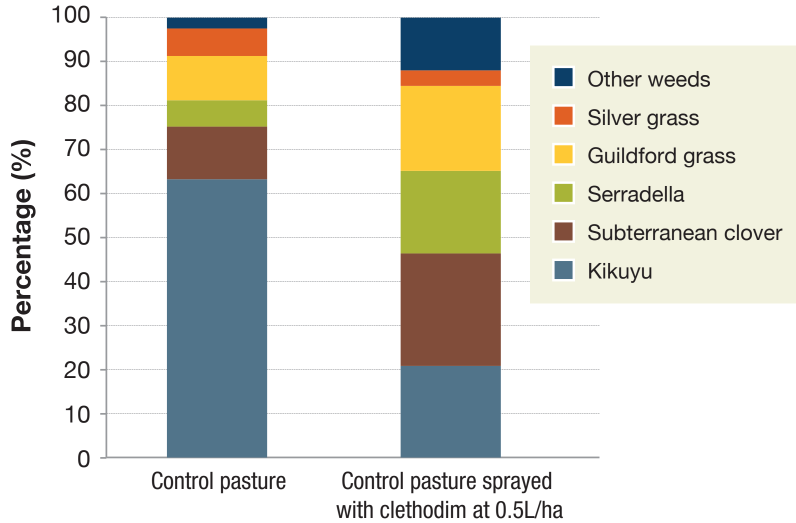

Figure 6. Botanical composition (%) of a kikuyu-based pasture sprayed with clethodim (0.5L/ha) following the break of season in May compared to untreated pasture in August 2014 in Esperance

The research data presented in Figure 7 demonstrates how effective the combination of suppression and sowing of subterranean clover can be in rapidly increasing the winter clover content of a kikuyu pasture located near Albany compared to sowing or suppression alone. The trial site consisted of a kikuyu/annual ryegrass pasture with complete kikuyu cover and with little or no clover content. Sowing clover in April lifted the legume content to comprise 2% of the cumulative biomass in winter. Just suppressing kikuyu with clethodim (0.5L/ha) in April increased clover content to 15% of the biomass. However, the combination of suppression and sowing substantially lifted legume content to 55% or 2100kg DM/ha compared to the control pasture, which contained no clover.

As expected, the clethodim knocked the annual ryegrass, which led to a loss of 1026kg DM/ha in total winter biomass in the suppression-only treatment. Most of that loss, however, was recovered by sowing subterranean clover in combination with suppression (Figure 7). In both treatments involving suppression, broadleaf weeds became a significant component of the pasture, suggesting that kikuyu had been suppressing these weeds for many years.

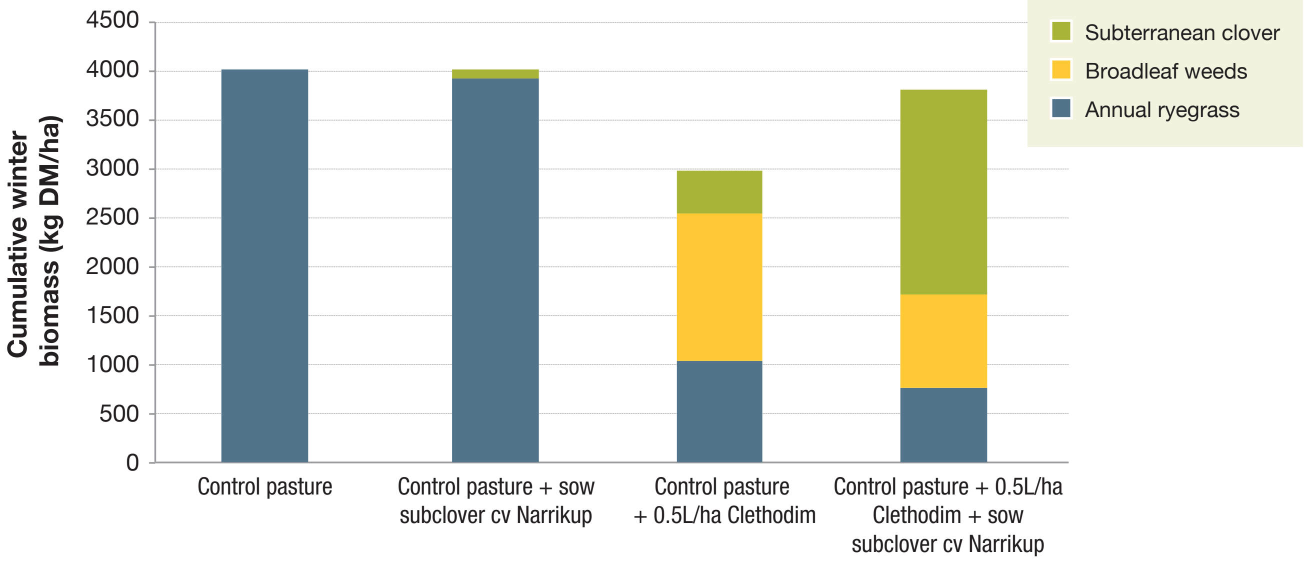

Figure 7. Cumulative winter biomass (kg DM/ha) and botanical composition (kg DM/ha) of a kikuyu-based pasture either sown to subterranean clover (April), sprayed with clethodim (0.5L/ha in April) or both sown to subterranean clover (April) and sprayed with clethodim (0.5L/ha in April) compared to untreated pasture in August 2015 in Albany

At the Esperance trial site in 2014, we also compared suppression-only to suppression combined with sowing. In this case, the control pasture consisted of kikuyu (53%), silver grass (35%) and subterranean clover (12%). While spraying the pasture in April with 2.5L/ha of glyphosate 450 grams (g)/L did increase clover content to 23% in winter, the removal of competition from kikuyu resulted in silver grass doubling to make up 73% of the sward (Figure 8). Sowing subterranean clover in combination with 2.5L/ha of glyphosate 450g/L lifted legume content further to 44% and reduced silver grass to 54%.

The Esperance results highlight how critical it is to control silver grass when suppressing kikuyu pastures that contain even low amounts of silver grass. In this situation, there are two options: either control silver grass in the years before suppression or include silver grass control with suppression. For further information on silver grass control, see ‘*Controlling weeds*’, page 26.

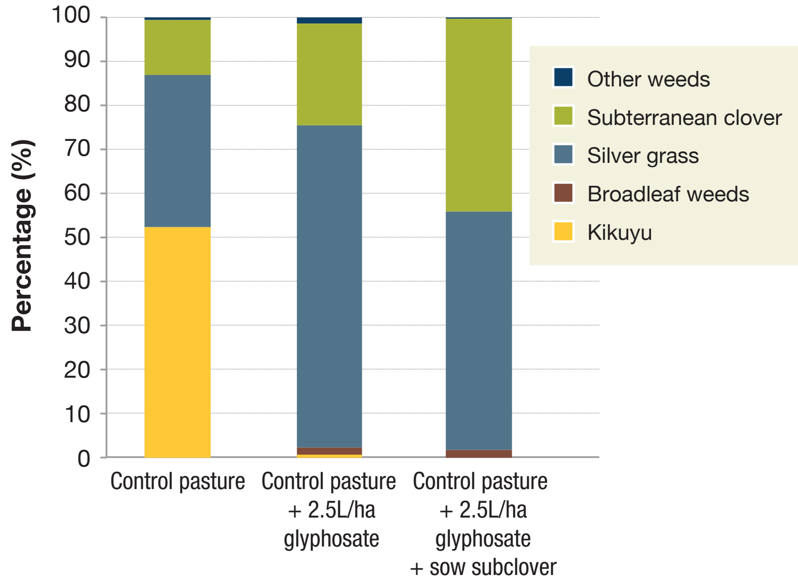

Figure 8. Botanical composition (%) of a kikuyu-based pasture either sprayed in April at 2.5L/ha with glyphosate 450g/L or both sown to subterranean clover (April) and sprayed in April at 2.5L/ha with glyphosate 450g/L compared to untreated pasture in August 2014 in Esperance

Kikuyu pasture in autumn with low legume content

If the legume seedbank is low, improving legume density will require reseeding

Sown subterranean clover establishing in a suppressed kikuyu pasture

Legume sowing techniques for subtropical grass pastures

Typically, annual legumes are sown using either conventional cultivation or direct seeding (e.g. drilling) in autumn following the break of season. While conventional cultivation is effective in annual pastures, it is not suited to established subtropical grass swards with mature perennial plants. In this case, direct seeding is the best option. Direct seeding was the technique used for most of the trial work presented in this publication. When direct seeding, ensure the sowing depth is correct, being careful not to sow too deep. Sowing depth will vary between species, based on seed size. When sowing into kikuyu, use a disc to cut through the kikuyu stolons and rhizomes.

During the research, producers were interested to know whether they could successfully establish annual legumes in subtropical grasses by simply broadcasting seed. In a number of the early trials, broadcasting was compared with direct seeding. In all cases, direct seeding was more successful than broadcasting (Figure 9).

Summer sowing is a new technique that provides an alternative to sowing in autumn. However, the technique requires the use of hard-seeded, unscarified legume seed or pod that softens over the first summer/autumn and subsequently germinates in autumn once the hard-seededness has broken down completely. The major advantage of summer sowing is that you can use legume seed or pods produced on-farm with minimal post-harvest processing.

We investigated the performance of summer-sowing serradella pod, using a drill, into subtropical grass pastures with particular interest in whether it could outperform conventional sowing of serradella seed in autumn. The results were mixed. In Wellstead in 2015, yellow serradella established more seedlings when sown as pod in summer yet the French serradella had a higher seedling count when sown as seed in autumn. At the same site, a mixture of yellow and French serradella seed sown in autumn did as well as any of the single species sown in either summer or autumn. However, by the end of winter, the summer-sown treatments had accumulated on average 489kg DM/ha (plus 25%) more biomass than those sown in autumn (Figure 10).

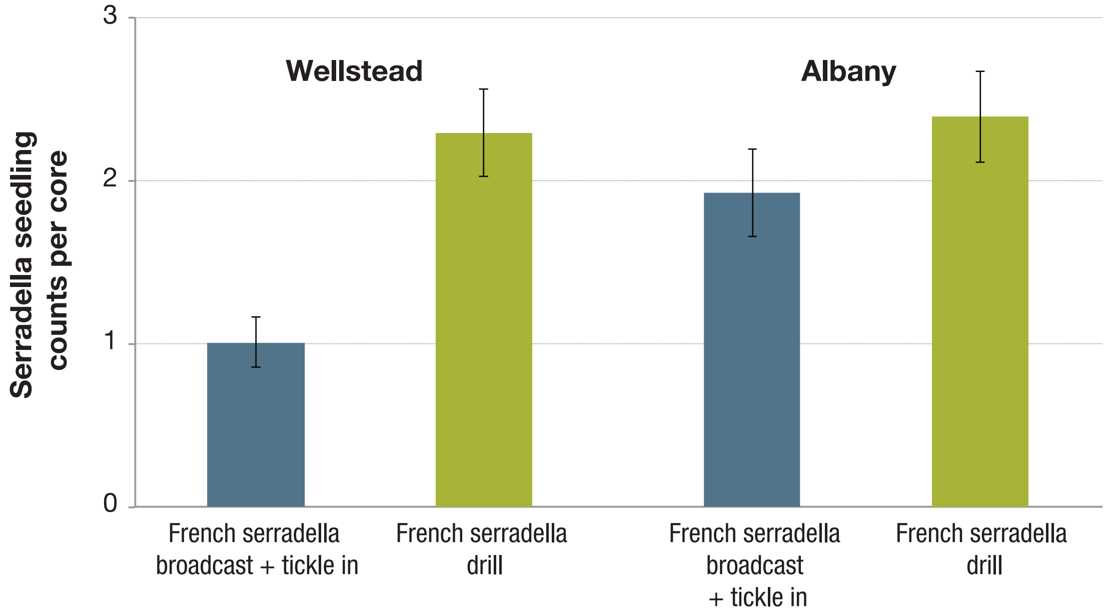

Figure 9. Serradella seedling establishment following either being sown by broadcast or drill at sites in Wellstead and Albany in May 2013. (Error bars represent standard error of the mean)

In the same year (2015) at a site in Esperance, the average cumulative winter biomass of summer-sown serradella compared to autumn-sown serradella was similar across three serradella cultivars (Figure 11), demonstrating that site and season can influence the outcome.

The biomass data from Wellstead suggests that at least in some seasons, summer-sown pod emerges earlier than winter-sown seed and can accumulate more winter biomass in the first year. Producers should also consider sowing a mixture of French and yellow serradella to reduce the risk of failure or poor performance.

Overall, the findings suggest serradella can be successfully established with either a summer or an autumn sowing and that the choice of sowing time will be made based on each producer's particular circumstances. Note that granular legume inoculant has made dry sowing of legumes in summer viable.

Yellow (left) and French serradella (right)

Serradella pods can be harvested and sown into subtropical grass pastures in summer

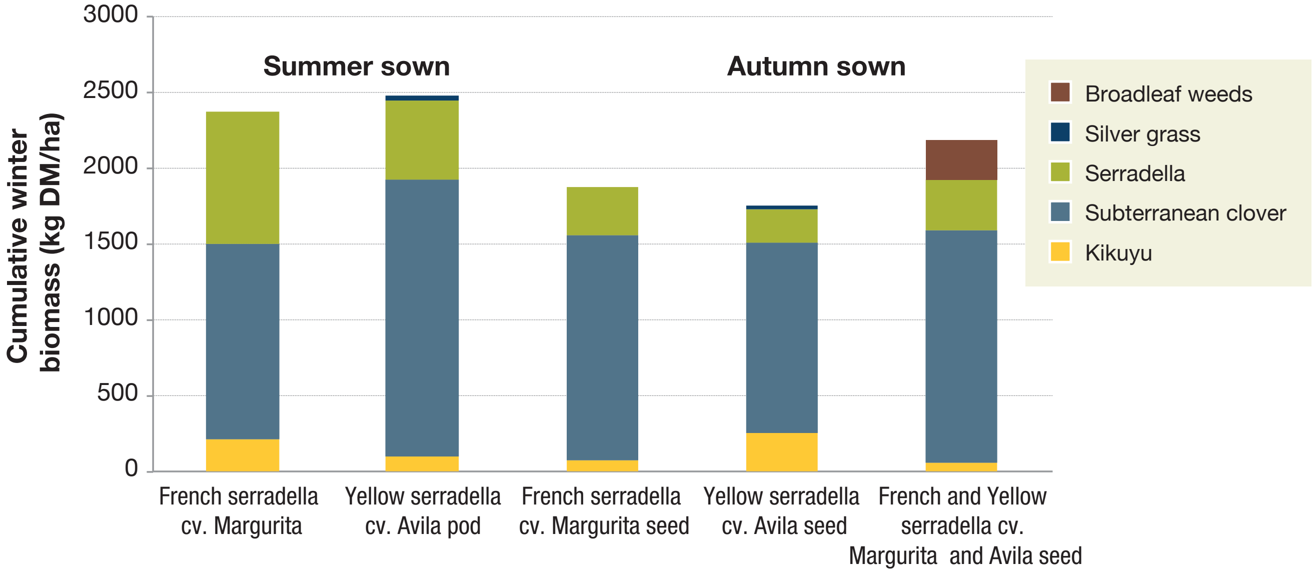

Figure 10. Cumulative winter biomass (kg DM/ha) and botanical composition of kikuyu treatments sown in either summer (February) or autumn (April) to French or yellow serradella (cultivars Margurita and Avila) in August 2015 in Wellstead. Note pod was sown in summer and scarified seed in autumn and kikuyu was suppressed with clethodim (0.5L/ha) following the break of season (third week of May)

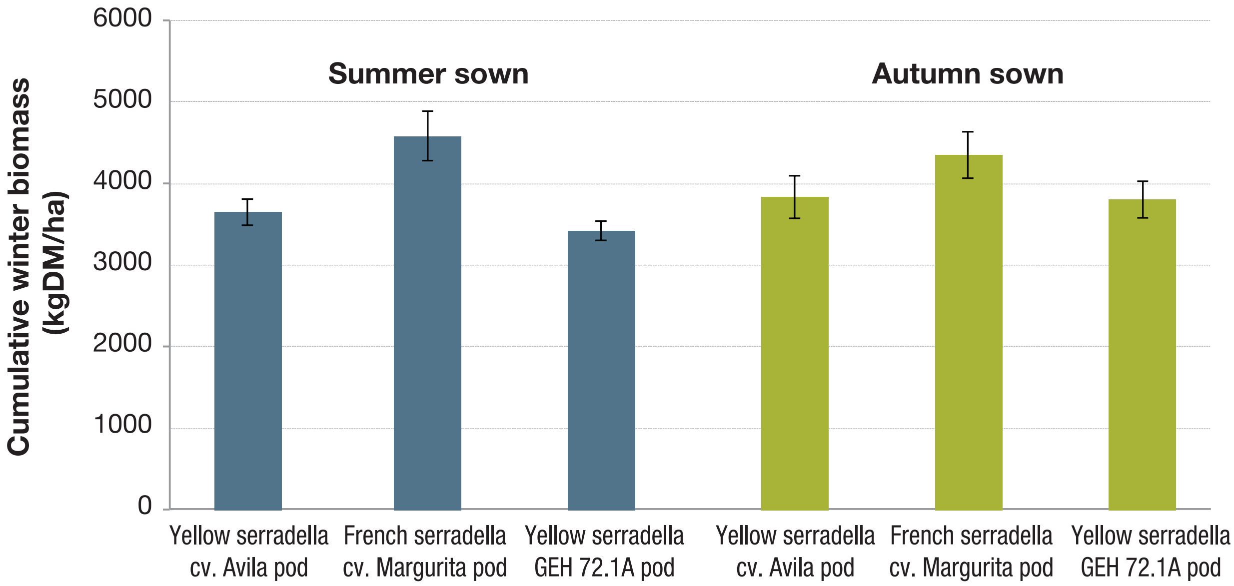

Figure 11. Cumulative winter biomass (kg DM/ha) of kikuyu treatments sown in either summer (February) or autumn (April) to French or yellow serradella (cultivars Margurita, Avila and accession GEH 72.1A) in August 2015 in Esperance. Note pod was sown in summer and scarified seed in autumn and kikuyu was suppressed with clethodim (0.5L/ha) following the off season (first week of May). (Error bars represent standard error)

LEFT: Sowing annual legumes into kikuyu in autumn at Wellstead trial site

RIGHT: Yellow serradella

Further reading

- Loi, A & Yates R n.d., *Twin sowing and summer sowing: alternative techniques to introduce annual legumes into pastures*, viewed 1 August 2017
  www.agric.wa.gov.au/pasture-establishment/twin-sowing-and-summer-sowing-alternative-techniques-introduce-annual-legumes

- Loi, A, Nutt, BJ, Yates, R & D'Antuono M 2012, *Summer sowing: a new alternative technique to introduce annual pasture legumes into mixed farming systems*, paper presented at the Australian Agronomy Conference, viewed 1 August 2017
  www.regional.org.au/au/asa/2012/pastures/7982_loia.htm

3. Increasing production

Key messages

- Addressing soil constraints is critical to ensuring a productive pasture.
- Most legumes are sensitive to pH which can lead to poor legume content on acid soils.
- Subterranean clover is highly responsive to soil phosphorous availability.
- Both potash and sulphur are essential for clover growth.
- Soil and tissue testing should be considered to manage clover nutrition.
- When suppressing kikuyu to lift legume content, consider controlling weeds as numbers can increase quickly once kikuyu is suppressed.
- Ryegrass and subterranean clover sown together increase winter production in suppressed kikuyu.
- Woolly pod vetch proved to be the most productive sown legume in kikuyu but there is uncertainty regarding its management.

Increasing the production of subtropical pastures requires the manager to consider a number of factors. In this section, we focus on addressing soil constraints to plant growth, controlling weeds and sowing productive annual species.

Addressing soil constraints

Soil acidity management

Across the south coast, a number of soil constraints can limit the productivity of subtropical grass pastures. These include soil acidity, nutrient constraints, non-wetting, wind erosion and waterlogging. In this section, we focus on soil acidity and nutrient constraints. Note that nitrogen supply is covered in '*Guidelines for fertiliser*', page 38.

Soil acidity is widespread across the south-west agricultural zone, with the south coast recording a high percentage of soils below the recommended target pH($CaCl_2$) of 5.5. The region has 88% of surface soils (0–10 centimetres) and 55% of subsurface soils (10–20 centimetres) below the target pH (DPIRD 2013) due to the dominance of sandy textured soils.

Subtropical grasses are tolerant of soil acidity. For example, kikuyu can tolerate highly acidic soils with a pH($CaCl_2$) as low as 4.0. However, lifting soil pH will not only benefit less tolerant companion species but also increase the yield of subtropical grasses. When aiming to increase production, it is critical to address soil acidity before sowing annual species.

Species such as subterranean clover are critical to provide pasture production in winter when subtropical grass growth rates are lowest. In addition, legumes lift soil fertility by fixing atmospheric nitrogen, which also lifts grass yield.

Most pasture legumes are not as tolerant of acidic soil as subtropical grasses and therefore soil amelioration, usually with lime, will be required to raise soil pH. The target pH for 0–10 centimetres (cm) is 5.5 and for 10–20cm is 4.8. Many soils across the south coast will require lime to reach these levels.

Alan Hawley (farmer) and Ron Masters (DPIRD) soil sampling for soil nutrient and pH mapping near Albany

Nutrient management of subterranean clover in subtropical pastures

An adequate level of soil nutrients (both macro and micro) is critical to maintain production and allow legumes such as subterranean clover to better compete with subtropical grasses.

Phosphorus (P) is a key macronutrient and subterranean clover can be highly responsive in P-deficient soils (see image below). Determining how much P to apply can be complex as there is a range of factors, such as the P-retention index of soils, the amount of available P and the production target which will determine the amount of P required.

The Colwell P test is used as a reasonable predictor of potential P deficiency and has been used to develop response curves from a collation of national trials.

Phosphorus response curves vary depending on pasture species, soil type and in particular the P buffering index (PBI), which essentially predicts the soil's ability to retain P (Figure 12).

Response of subterranean clover to increasing rates of P (0–100% of estimated P required for maximum growth)

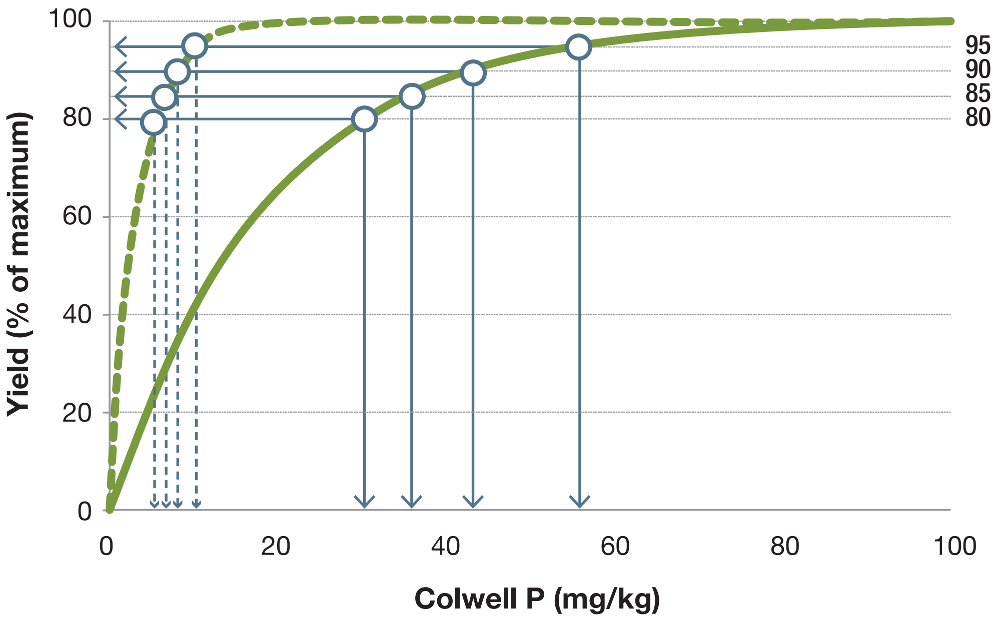

Figure 12. Colwell P levels needed to achieve 80–95% of maximum production on a low PBI soil, e.g. sand (dashed line) and a high PBI soil e.g. loam (solid line) (Summers and Weaver 2011)

To accurately determine how much P to apply, you need to determine both the PBI and Colwell P levels from a representative soil test. An estimate of the production target or relative yield (% of maximum production) will also need to be made. These are then used to estimate P required (Figure 12).

Taking soil samples for testing

Potassium (K) is also critical to clover growth; however, the response of subterranean clover to K does not appear to be as robust as for P. As a result, it is generally accepted that productive clover pastures should have a Colwell K level of >100 milligrams (mg)/kg in sandy soils. The application of about 1kg of K/ha will be needed to raise the soil test by one unit for most soils up to a PBI of 300. For soils with a PBI >300, about 2kg of K/ha are required to increase the soil test by one unit.

The critical levels of sulphur (S) used to assess soil tests are derived from Australian standards. The S soil test is classified as high S status when the value is >5.9mg S/kg (90% of maximum production). Sandier low PBI soils are more likely to need S applications, as the S can leach from these soils. The need for S is commonly associated with the need for K in spring on clover pastures grown on sandy soils after winter rains.

Micronutrients are very important for clover growth. However, soil tests are unreliable and so tissue testing is recommended. Copper (Cu) and Zinc (Zn) do not leach, so the primary mechanism of loss is through product removal. As a result, micronutrient levels only drop slowly. Small amounts are needed and it is highly recommended that tissue testing be undertaken before any application of Cu or Zn.

Spreading fertiliser on pasture

Further reading

- Department of Primary Industries and Regional Development Western Australia n.d., *Soil nutrients*, viewed 1 August 2017
  www.agric.wa.gov.au/climate-land-water/soils/soil-constraints/soil-nutrients

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- Gazey, C & Davies, S 2009, 'Soil acidity: a guide for WA farmers and consultants', *Bulletin* 4784, Department of Agriculture and Food, Western Australia, Perth, viewed 1 August 2017
  researchlibrary.agric.wa.gov.au/bulletins/31/

- Summers, R & Weaver, D 2011, 'Soil test and phosphorus rate for high rainfall clover pastures', *Bulletin* 4829, Department of Agriculture and Food, Western Australia, Perth, viewed 1 August 2017
  researchlibrary.agric.wa.gov.au/bulletins/64/

- Department of Agriculture and Food, Western Australia 2013, 'Report card on sustainable natural resource use in agriculture: status and trend in the agricultural areas of the south-west of Western Australia', Department of Agriculture and Food, Western Australia, Perth, viewed 1 August 2017
  researchlibrary.agric.wa.gov.au/books/12/

- *Pasture nutrient applications 2013*, Meat & Livestock Australia, viewed 1 August 2017
  mbfp.mla.com.au/Pasture-growth/Tool-29-Pasture-nutrient-applications

Controlling weeds

Herbicides

In a subtropical grass paddock, maintaining desirable species such as subterranean clover or annual ryegrass will improve both feed quantity and quality. If lacking, productive annual species can be regenerated or established in pastures such as kikuyu by suppressing the grass with selective herbicides, grazing or a combination of both. Suppression can, however, lead to an increase in weed populations that previously were inhibited by kikuyu. It is therefore important that weeds are managed as part of any program to increase annual legume and annual grass composition.

Silver grass is a particularly problematic and common weed in kikuyu swards across the south coast. While it is suppressed in part by kikuyu, it persists nonetheless. Silver grass germinates early in the growing season and sets seed early in spring. It can become dominant over autumn and winter, reducing pasture productivity. The feed quality of silver grass is poor and it declines rapidly as the season progresses to a point where it is not sufficient to even maintain stock.

Silver grass

Selective herbicide options for silver grass control in pastures are limited. The most commonly used options include simazine, propyzamide and to a lesser degree imazapic. There are several other herbicide options; however, they can cause significant damage to subterranean clover or serradella.

Simazine needs to be incorporated with moisture and for best results must be sprayed as a pre-emergent control. If it is sprayed and rain does not occur, then it is likely to have limited impact. There are also differing varieties of silver grass, one or more of which appear to have some resistance to simazine. This can result in higher than expected rates needed to achieve effective (90%) control (Table 1). However, with the right mix of rainfall and timing, simazine can be effective and cheap.

Kikuyu pasture which has been sprayed with clethodim and simazine to suppress the kikuyu and control silver grass, respectively. (Note the unaffected serradella)

Propyzamide can also be used as a pre- and post-emergent herbicide. For silver grass control, pre-emergence applications are generally more effective. Later applications can be successful; however, higher rates will generally be required for adequate (90%) control (Table 1).

Imazapic can effectively control silver grass but its effect on clover and serradella can be significant, which would rule it out if the goal was to increase legume content in a mixed sward. However, it has shown itself to be effective in trials and would be an option in low legume situations (Table 1).

For paddocks without a history of simazine use, it is worth applying trial strips to determine whether simazine is going to be effective. If not, using either propyzamide or imazapic to control silver grass would be another option.

The grass-selective herbicide, clethodim, which effectively suppresses kikuyu, also suppresses (but does not kill) silver grass, if sprayed early at the one- or two-leaf stage. If silver grass is still active three or four weeks after using clethodim, then control using simazine or propyzamide may still be an option.

Spraytopping can be an effective way of reducing the seedset of silver grass in kikuyu. Seed dormancy in silver grass is around two years, so if silver grass content is high, it may be necessary to spraytop for two years. Sublethal doses of either glyphosate or paraquat can be used for spraytopping. The silver grass, however, must be sprayed before haying off, ideally when the seed is at the soft dough stage. If in doubt, spray earlier. The pasture can then be grazed to allow stock to nip off any fresh tillers. If grazing fails to control regrowth, then a respray will be necessary.

Cropping kikuyu is another effective method of cleaning up weeds, renovating the pasture and improving profits. Since the aim is to produce a plant-free seedbed for sowing a crop, glyphosate is used at a rate of at least 1–2L/ha (glyphosate 450g/L) before the break of season. This could then be followed up with a second knockdown herbicide as required. Control with herbicides plus competition from the crop can significantly reduce weed species.

Another option is the use of a wick wiper to knock down silver grass late in the season just before seedset.

Table 1. Silver grass, serradella and subterranean clover tolerance to eight grass-selective herbicides in a kikuyu pasture suppressed with either clethodim or glyphosate

Trade name	Active ingredient	Label rate	Trial rate range	Silver grass assessment 90 days after application. Rate mL or g/ha for 90% control	Rate for 10% visual reduction in serradella at 90 days (mL or g/ha)	Rate for 10% visual reduction in subterranean clover at 90 days (mL or g/ha)
Flame on clethodim	*Imazapic*	NR	16–1600mL/ha	>1359	193	22
Flame on Glyphosate	*Imazapic*	NR	16–1600mL/ha	>1600	105	<16
Kerb on clethodim	*Propyzamide*	1000–1500g	40–4000mL/ha	3132	>4000	2340
Kerb on Glyphosate	*Propyzamide*	1000–1500g	40–4000mL/ha	3132	>4000	>4000
Simazine900 on clethodim	*Simazine*	400–550g	50–5000g/ha	1623	497	1215
Simazine900 on Glyphosate	*Simazine*	400–550g	50–5000g/ha	1752	655	2227

Examination of a kikuyu pasture dominated by subterranean clover in spring. (Note the presence of silver grass seedheads)

Trial site in Esperance in spring demonstrating how problematic silver grass can be once kikuyu is suppressed. (Note woolly pod vetch plot in the foreground in which the vetch has dominated the silver grass)

Plant competition

Research in Esperance and Wellstead has demonstrated that some pasture species compete well with silver grass and other problem weeds — for example, woolly pod vetch, annual ryegrass and kikuyu (Figure 13). In Esperance, following the suppression of kikuyu with glyphosate, the subterranean clover content increased from 12 to 23% and silver grass from 35 to 63%, indicating that kikuyu was dominating both species and that subterranean clover does not compete well with silver grass.

Supressing kikuyu and sowing a mix of subterranean clover and annual ryegrass resulted in an increase in both sown species but silver grass content also increased. The only sown legume that increased legume density and reduced silver grass was woolly pod vetch (Figure 13).

In summary, while sowing legumes can increase legume content, if grass suppression is used, weeds may also increase unless control measures are taken.

See '*Pasture cropping*', page 42, for more information.

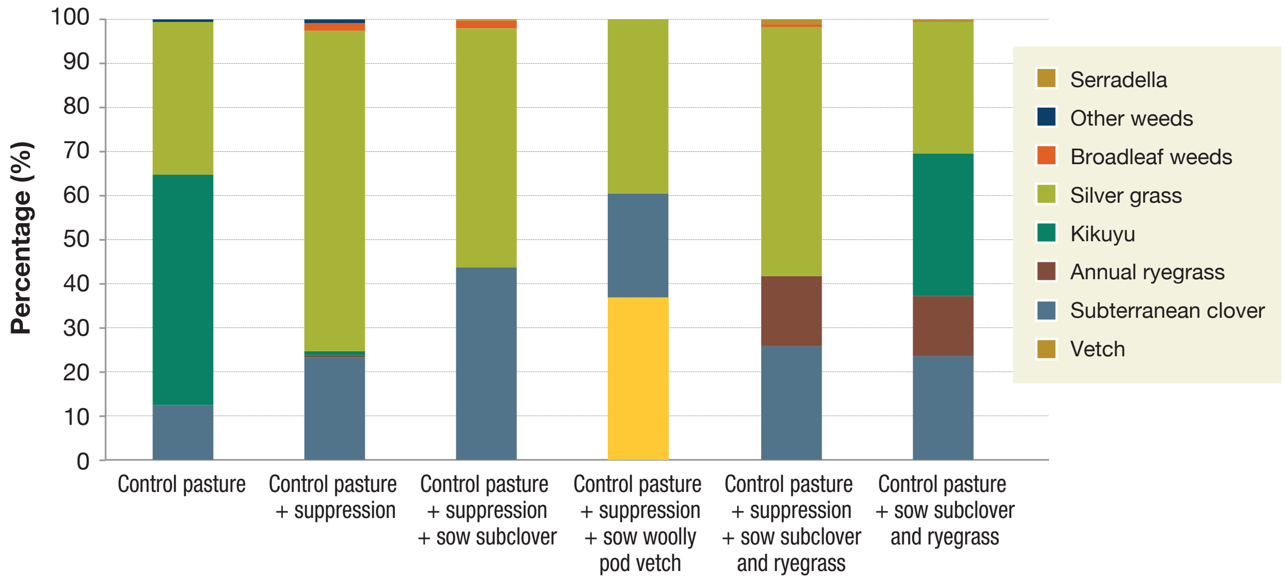


Figure 13. Botanical composition of winter-sown plots in kikuyu suppressed with clethodim and glyphosate in Condingup, Esperance, in August 2014

Very productive legumes

One of our recent research goals has been to identify legumes that have the ability to substantially increase the yield of kikuyu pastures like annual ryegrass. Results from a trial in a medium rainfall environment have hinted that woolly pod vetch might be one such candidate, suggesting that large-seeded legumes could increase yield possibly due to greater seedling vigour compared to small-seeded legumes.

Further support for this was evident at the Esperance site in 2014 and 2015 (see Figures 14 and 15). While the woolly pod vetch treatment produced the most winter biomass in both years, it was particularly impressive in 2015, yielding 2300kg DM/ha more than the untreated control.

Unfortunately, woolly pod vetch did not consistently increase dry matter production at all field sites in all seasons, suggesting that further research is required to understand the conditions required to reliably lift yield. However, given that woolly pod vetch requires soils with a pH($CaCl_2$) of 5 or higher, good soil fertility and high rainfall, it is likely to perform well in these conditions. Other concerns include grazing management and recruitment from seed. While we did observe recruitment in following seasons at trial sites, overall it was poor.

Unfortunately, woolly pod vetch seed cannot be fed to livestock as it is potentially toxic and can cause death (see Enneking 1995 in '*Further reading*', page 30 for more detail). It is recommended that woolly pod vetch is only grazed from the 10-node stage until podding. It can, however, be cut for hay/silage.

In summary, addressing soil constraints is the first step to developing a highly productive subtropical grass pasture followed by sowing a productive annual species. The most reliable of these is subterranean clover or annual ryegrass with ryegrass proven to substantially lift winter production. For those wishing to experiment with something different, woolly pod vetch may be an alternative, but expect some trial and error.

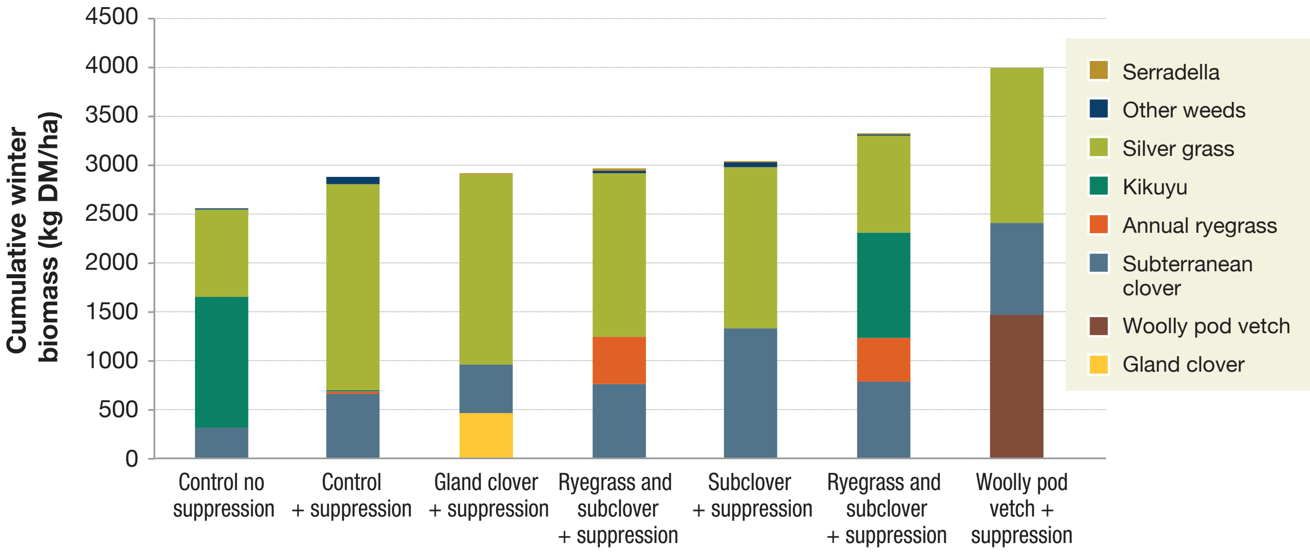


Figure 14. Cumulative winter biomass (kg DM/ha) and botanical composition of a range of treatments, including legume species and cultivars sown into a suppressed kikuyu pasture, an unsuppressed control and a suppressed unsown control at Esperance in August 2014

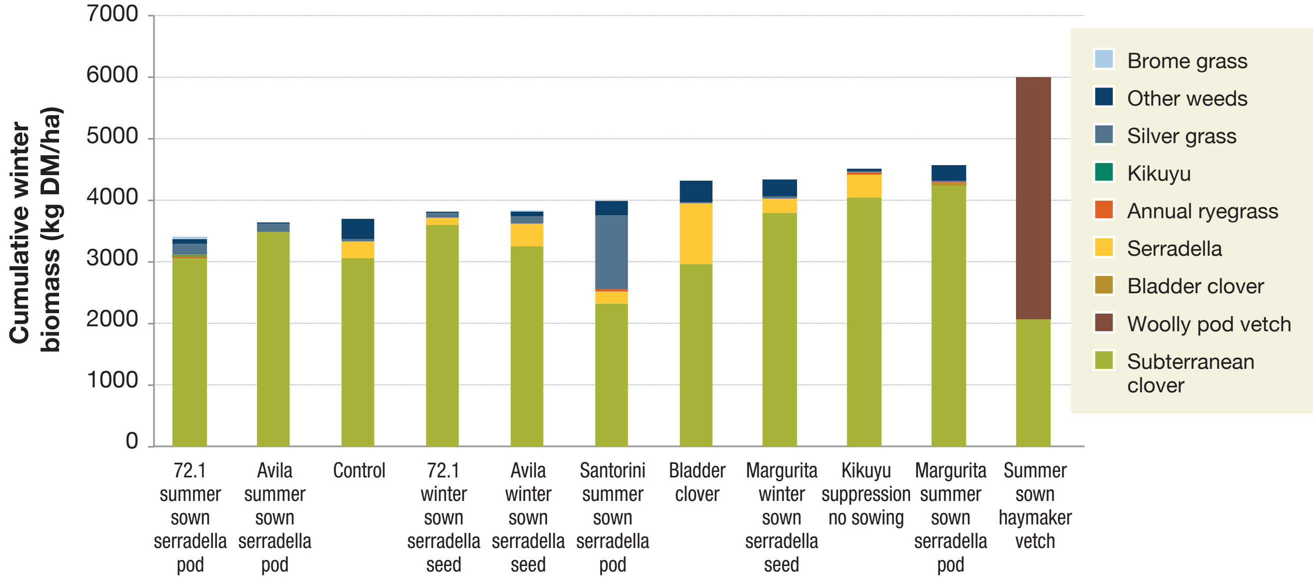


Figure 15. Cumulative winter biomass (kg DM/ha) and botanical composition of a range of treatments, including legume species and cultivars sown in either summer or winter into a suppressed kikuyu pasture, an unsuppressed control and a suppressed unsown control at Esperance in August 2015

Further reading

- Enneking, D 1995, *The toxicity of Vicia species and their utilisation as grain legumes*, PhD Ag.Sc. (Adelaide), viewed 16 August 2017 members.westnet.com.au/enneking/pdf/pubs/Enneking_1995_Vicia_toxicity.PDF

RIGHT: Strip of woolly pod vetch sown into a suppressed kikuyu pasture in spring in Wellstead

4. Grazing management

Key messages

- Kikuyu is productive and persistent under intensive and frequent grazing (e.g. set stocking).
- Tufted or upright subtropical grasses like panic require a period of rest following grazing to ensure persistence and high yield.
- No single grazing method will be able to meet every different animal and pasture objective. The best approach is to tactically use different grazing methods based on seasonal conditions and livestock and pasture requirements.

Grazing method is critical to efficient pasture and animal management. In the case of subtropical grass-based pastures, the choice of grazing method is particularly important to ensure perennial grass will persist while pasture use and livestock performance is maximised.

The most common grazing systems are set stocked and rotational (or time-based) grazing. With tufted subtropical grasses, such as panic, some form of rotational grazing is essential to ensure it will persist in the medium to long term. Kikuyu, however, will persist under set stocking because of its rhizomatous nature and can, in fact, respond favourably to high grazing pressure. It appears that the tufted subtropicals can tolerate set stocking under cattle but not sheep.

There is considerable interest among livestock producers in using different grazing methods to improve productivity and maintain desirable pasture species. Historically, set stocking was the only grazing method used with annual pastures. Under this system, the same number of stock were moved from paddock to paddock on an ad hoc basis and kept in each paddock for varying periods, in some cases, months. Under the rotational grazing system, stock are moved frequently through a series of paddocks.

The main difference is that set stocking largely enables the animals to control where, when and which plants they eat. With rotational grazing (and higher grazing pressure), the animals have less ability to choose. An advantage of the rotational system is that the producer can decide when and for how long a pasture will be grazed and rested.

This section briefly discusses the way in which different grazing methods affect the production and persistence of subtropical grass pasture and stock production.

Sheep grazing tight paddock with little option to select specific pasture species

Different grazing methods

Grazing method is a management technique available to producers to achieve a specific objective. While some producers can become confused when confronted with the many systems available (e.g. set stocking, rotational grazing, strip grazing and cell grazing), in fact, they all fall on a continuum between the two extremes — that is, (strict) set stocking and intensive rotational grazing.

Under (strict) set stocking, animals remain in one paddock for the whole year and the pasture receives no rest. However, very few producers use this grazing method in its strict sense but rather leave stock in the same paddock for long periods, especially during the growing season. Intensive rotational grazing involves moving stock daily and (in some cases) more than once per day, with pastures receiving a long rest between grazing.

With rotational grazing, stock are moved based on time (e.g. under a four-paddock system with two weeks of grazing followed by six weeks of rest), variable recovery time, plant growth stage (e.g. 3-leaf stage), animal intake (e.g. maintain maximum intake) or feed on offer (FOO).

Another key factor in rotational grazing is the number of paddocks in a rotation. As the number of paddocks increases the:

- grazing period for each paddock decreases
- stocking pressure during grazing increases
- rest period for each paddock increases
- animals' ability to graze selectively is reduced
- average stocking rate (i.e. grazing days/ha) stays the same.

In reality, each system has advantages and disadvantages and no single grazing method will be able to meet every different animal and pasture objective. The best approach is to tactically use different grazing methods based on seasonal conditions and livestock and pasture requirements.

For example, in situations of feed deficit, rotational grazing allows better control over the regrowth period than set stocking, and can be used to restrict livestock intake. Conversely, in a situation of feed surplus, set stocking at high stocking rates can be used to control FOO and allow animals to select a high-quality diet leading to maximum liveweight gain.

Cattle grazing a subtropical grass pasture

Pasture production

Optimising pasture production depends on controlling two variables: the residual FOO following grazing and the length of time pastures are allowed for regrowth. If residual FOO is too low, pasture growth will initially be slow due to the low leaf area available for photosynthesis. If the period of regrowth is short, then pastures will only experience high growth rates for short periods or not at all. Conversely, feed quality declines as plants mature, so there can also be a trade-off between biomass production and quality.

In all grazing methods that have the objective of maximising production, producers need to monitor pasture and use indicators to maintain pastures at optimum FOO for pasture growth for the longest possible time.

Refer to the sections below for specific guidelines for grazing kikuyu or panic pastures.

Subtropical grass persistence

Tufted or upright subtropical grasses like panic require rest following grazing to allow the plants to replenish their below-ground reserves, complete seedset or retain protective sheaths under moisture stress. Being very palatable to stock, it is easily grazed out of pastures that are not rested.

Subtropical grasses store carbohydrate in their crown, stolons and rhizomes and use this energy for the initial regrowth following grazing, to persist through periods of stress (e.g. drought) and for regrowth. If the carbohydrate reserves are continually exhausted and not fully replenished, then stand density will gradually decline.

If the key with annual pastures is to manage the seedbank, the key to persistence of perennial grasses is to manage the carbohydrate reserves.

Research has shown that perennial grasses, when set stocked, persist better under cattle than sheep, most likely because sheep are more selective and graze more closely than cattle. In summer, selective close grazing by sheep would result in a greater loss of perennial plants than cattle at a similar stocking rate.

The appropriate grazing method for kikuyu and panic is discussed below.

Animal production

It is generally recognised that rotational grazing increases pasture dry matter and allows higher stocking rates. Yet, set stocking allows animals to select a high-quality diet, increasing the weight gain per head in the short term. In the medium to long term, however, this may lead to the loss of the most palatable or highest quality pasture species so animal production may decline.

The combination of set stocking and high stocking rates can lead to an increase in subterranean clover content, which can also improve performance per head. In contrast, rotational grazing usually leads to an increase in the grass component, which increases production per hectare.

Large paddocks often contain areas of pasture that are ungrazed or grazed infrequently. If large paddocks are subdivided and rotationally grazed, pasture that was previously under-used will be consumed, leading to an increase in production. A similar result can be obtained by grazing large paddocks with big mobs, thus reducing selective grazing by livestock.

Rotational grazing can be used as a tool to assist in the control of internal parasites, either by using cattle to 'clean up' a pasture for sheep or ensuring that livestock are not exposed to heavy worm larval pick-up. This requires planning and knowledge of larval survival patterns. In set-stocking situations, clean paddocks can be prepared.

Kikuyu grazing management

Kikuyu can be continuously grazed; however, rotational grazing at high stocking rates in summer and autumn when plant growth rates are low may be beneficial to maximise dry matter production.

Newly sown kikuyu pastures can be grazed once runners are 20cm or longer and have developed strong roots. Graze for a short period with high stocking rates (i.e. 100 dry sheep equivalents/ha). New stands should be monitored during grazing and stock removed if they are pulling out runners.

Continuously grazed kikuyu with a high percentage of young leaf

Just before the break of the growing season, kikuyu stands need to be grazed hard (down to 800–1000kg DM/ha) to open up the sward and allow space for annual legumes to establish. If this is not possible, consider suppressing kikuyu with a chemical (see '*Improving legume content*', page 14).

After the autumn break, it is essential to maintain kikuyu-based pastures at 800–1400kg DM/ha by grazing pastures using high stock density. Grazing from 2cm will give a dense 'turf-like' pasture; grazing from 5cm will give a more upright pasture. This will maximise pasture quality and allow light penetration for good establishment of annual clover and winter-active annual grasses.

In winter, maintain kikuyu-based pasture at 1400–3000kg DM/ha. Manage mixed pastures to encourage annual legumes. Aim to have a high percentage of clover and annual grasses. This will provide sufficient winter feed for stock, as kikuyu virtually stops growing during colder months.

In spring, keep pastures to 1000–1400kg DM/ha (around 2–5cm, depending on density). In late spring and early summer, apply higher stock densities and maintain at or below 3000kg DM/ha to prevent rank material accumulating.

In summer, use high stock densities to graze to 800kg DM/ha (around 1cm or less). This maintains pasture quality and minimises the build-up of rank material that inhibits germination of winter-active annual pastures in autumn. As summer rain will stimulate kikuyu growth, increase grazing intensity after each rainfall event to keep pasture below 3000kg DM/ha.

If you are managing kikuyu/subterranean clover pasture with rotational grazing, research suggests that an optimum rotation is:

- pre-grazing FOO of 2600kg DM/ha in winter and 3800kg DM/ha in spring
- residual FOO at the end of the grazing of at least 1400kg DM/ha
- rest periods between grazing varying from 60 days in winter to 30 days in spring.

Panic grazing management

Subtropical grasses like panic have the highest quality in the vegetative stage. Frequent grazing will increase the amount of leaf relative to stem, thus improving feed quality. As a rule, panic grass requires some form of rotational grazing to persist. However, it can tolerate continuous grazing by cattle at modest stocking rates, particularly when growth rates are high in spring and summer.

Following establishment in spring, avoid grazing until the plants have flowered and set seed or until the following autumn once the pasture has reached sufficient biomass. Stock can pull out plants that are grazed too early. You can test this by pulling plants by hand. Do not graze until they are firmly anchored. When grazing a new stand, use a high stocking rate for a short time to ensure the plants are not overgrazed.

BELOW: Panic grass growing on sand with serradella as a companion legume

To maintain mature panic pastures with a large proportion of nutritious leaf, rotationally graze the pastures at high stock densities. Be flexible, depending on conditions. In wet summers, graze for 7–10 days, allowing a rest of 3–4 weeks for regrowth. In dry summers, the rest period needs to be longer—six weeks or more and grazing should only commence if regrowth has been sufficient. Be aware that panic is susceptible to overgrazing in dry conditions. FOO can be used as an indicator, with grazing commencing at around 3000kg DM/ha and leaving a residual of about 1500kg DM/ha.

In winter, panic can be set stocked at modest rates if there is a strong annual legume companion with adequate growth rates.

Panic may be grown with other subtropical grasses such as Rhodes grass. If so, stock may preferentially graze the panic leading to its demise and the dominance of the lower quality companion. In this case, graze at a high stocking rate for a short period to prevent preferential grazing or graze when both grasses are equally palatable in the green-leaf vegetative stage.

If you overgraze a panic stand, allow a longer rest for plant recovery.

Grazed panic grass at around the point stock should be removed

Further reading

- *Grazing management 2016*, Meat & Livestock, viewed 1 August 2017
  www.mla.com.au/research-and-development/Environment-sustainability/Sustainable-grazing-a-producer-resource/grazing-management/
- *Grazing & pasture management 2016*, Meat & Livestock Australia, viewed 1 August 2017
  www.mla.com.au/research-and-development/Grazing-pasture-management/
- EverGraze n.d., On-farm options – grazing management, viewed 1 August 2017
  www.evergraze.com.au/library-content/grazing-management/

5. Guidelines for fertiliser use in subtropical grass pastures

Key messages

- Applying nitrogen, irrespective of season, increased subtropical grass pasture yield.
- Application rates of 25kg N/ha provided the most efficient conversion of N to biomass.
- Valuable increases in production can be achieved in the summer and autumn feed gaps with the use of fertiliser N in conjunction with adequate soil moisture.
- Spring responses to applied N were high; however, it would not make economic sense to use N unless you intend to conserve the feed.
- Applying phosphorus to meet the subterranean clover demand in a mixed kikuyu–clover sward will meet the P requirements of kikuyu.
- While kikuyu will respond to P, it will only do so at Colwell P levels so low that they are unlikely to be found in a paddock.

Fertiliser use in subtropical grass pastures has generally focused on the nutrient requirements of the companion legume such as subterranean clover. The assumption has been that the legume has a higher requirement for phosphorus (P), potassium (K) and sulphur (S) and therefore the grass will have more than adequate nutrition and the productive legume will provide sufficient nitrogen (N) to drive grass yield. Recent research has shown that this assumption, at least for phosphorus, is valid. However, there are opportunities to use tactical applications of N to increase productivity further if stocking rates are high enough to warrant it or if feed is short (e.g. in summer and autumn).

Nitrogen response in kikuyu

Nitrogen is essential for growth of pasture plants. It also improves pasture quality as protein content is directly related to its N content. Legumes such as subterranean clover can fix atmospheric N via root nodules but grasses, including subtropical grasses, rely entirely on soil N to meet their requirements.

Like many subtropical grasses, kikuyu is very responsive to N. If soil-available N is low, it will respond to applied N with increased growth and yield. As a warm season grass, it is most responsive in the warmer months, particularly in spring, summer and autumn.

The response of kikuyu to N application at different times of the year in Cranbrook can be seen in Figure 16. The largest response recorded was in spring and summer.

Assessing kikuyu pasture yield using exclusion cages

While applying N consistently increases pasture yield, it is important to identify which rates are most efficient in terms of how many kilograms of dry matter is produced for every kilogram of N applied. This will give an indication of when the largest benefit will be gained from every kilogram of N applied. The Cranbrook field trial indicated that for all seasons other than spring, 25kg/ha of N was the most efficient.

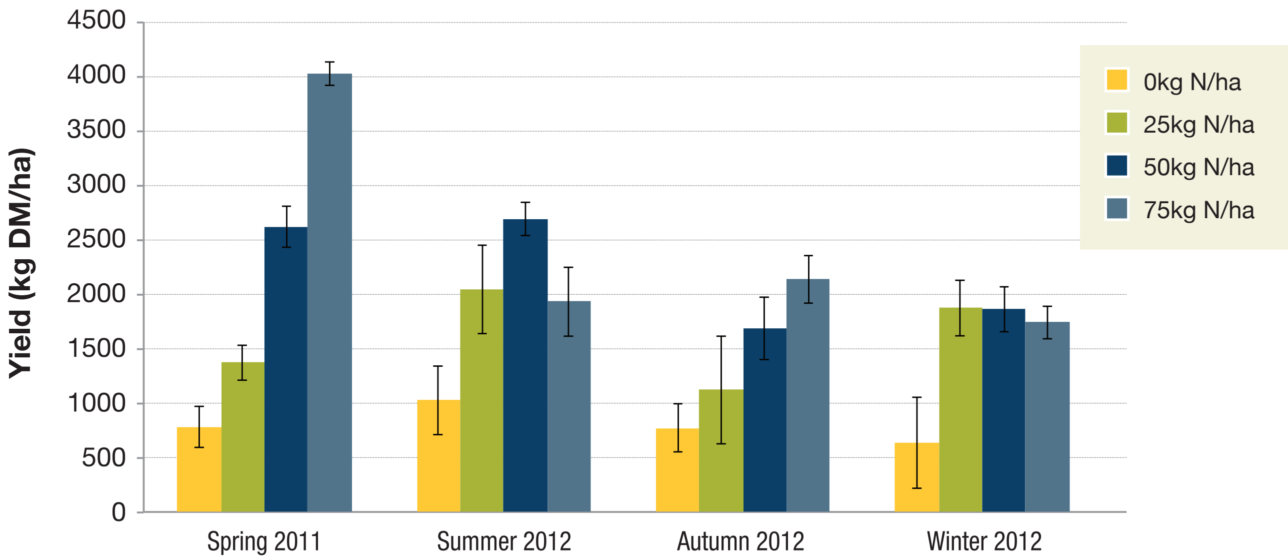


Figure 16. Seasonal yield response (kg DM/ha) of kikuyu pasture to applied N at three different rates applied as urea at Cranbrook. Periods over which yield was measured: spring 2011 – 9 Sep to 30 Nov; summer 2012 – 1 Dec to 18 Apr; autumn 2012 – 19 Apr to 6 Jul; and winter 2012 – 7 Jul to 12 Sep. Rainfall received in spring 2011, summer 2012, autumn 2012 and winter 2012 was 209, 86, 133 and 112 millimetres (mm) respectively

The response of kikuyu to applied N is influenced by the availability of moisture and temperature. Only in the wet spring of 2011 did yields respond to N rates above 25kg/ha N, indicating the requirement for adequate soil moisture to drive the N response. The summer response in Figure 16 shows a substantial increase in production—up to 50kg/ha. Above this, the yield declined, most likely due to a lack of soil moisture.

While kikuyu does respond to applied N in winter, the lower temperatures constrain growth. A better option is to apply N to ryegrass pastures that have far higher cold tolerance and will produce more feed at this time. Also, from a farming systems perspective, rather than apply N to kikuyu in the colder months, encourage high legume content instead. This will provide feed in winter and contribute N to the system, which will lift kikuyu production in the warmer months.

As shown, the application of N can substantially lift kikuyu production; however, producers need to consider the economic return when using this tactic (i.e. when the additional feed produced will be most valuable to their livestock business). Given the most efficient application rate of N is 25kg/ha N, this rate in both summer and autumn is likely to provide the best return.

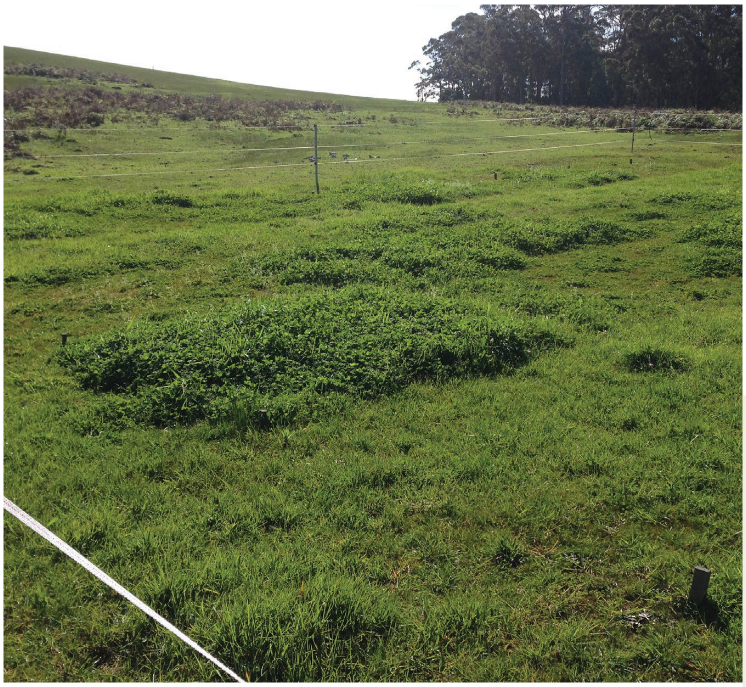
Phosphorus response in kikuyu

Phosphorus management in kikuyu swards has focused on ensuring the annual legume component has adequate soil-available P to remain productive. This strategy is based on the reasonable assumption that subtropical grasses have a lower P requirement than legumes.

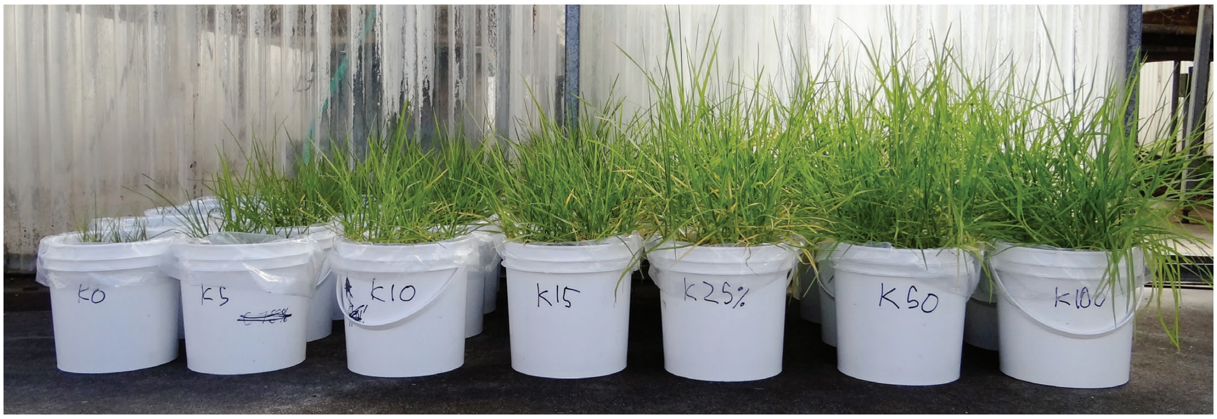
Analyses of soil tests taken from pastures across the south-west over many decades have shown that a large number of paddocks have a significant P reserve as a result of a long history of superphosphate application. Kikuyu, like all plants, requires P for growth and reproduction; however, it is likely that most soils have sufficient P to meet its requirements. This is based on recent research that has developed a P response curve for kikuyu.

The images on page 41 shows a strong response from both kikuyu and subterranean clover to increasing amounts of applied P. However, kikuyu had no significant response above 100kg P/ha or 50% of the recommended rate for clover. In contrast, clover demonstrated a sustained response between 50% and even 100% of the recommended application rate. This indicates that clover has a higher P requirement than kikuyu, as would be expected.

Further P response trials were carried out at two field sites with existing kikuyu pasture and a history of low superphosphate application. The first site had sandy soil with a low PBI and the other red loam with a high PBI. Results showed no response from kikuyu to applied P on either the sand or loam site, which was surprising given the responses to P seen in the glasshouse trial. Subterranean clover however had a substantial response to applied P at the loam site (see image below).



Hazelvale site near Walpole showing substantial clover response. (Note the lack of response in the kikuyu treatment in the foreground)



The growth of kikuyu and subterranean clover at the equivalent of 11, 22, 33, 54, 109 and 217kg/ha of superphosphate

Kikuyu has a very deep root system (>3 metres) and is able to scavenge nutrients like P from depth. The field trial in the image on page 40 demonstrates that while the clover was responding to the applied P, the kikuyu was not. This trial had deficient levels of P in the top 10cm. However, the kikuyu was able to access P from a much deeper depth. This suggests that a paddock would have to be extremely P deficient to show a response in kikuyu to applied P.

Further reading

- Summers, R & Weaver, D 2011, 'Soil test and phosphorus rate for high rainfall clover pastures', *Bulletin 4829*, Department of Agriculture and Food, Western Australia, Perth, viewed 1 August 2017
  researchlibrary.agric.wa.gov.au/bulletins/64/

- Summers, R & Weaver, D n.d., *Phosphorus for high rainfall clover pastures*, Department of Agriculture and Food, Western Australia, viewed 1 August 2017
  www.agric.wa.gov.au/soil-nutrients/phosphorus-high-rainfall-clover-pastures

6. Pasture cropping subtropical grass pastures

Key messages

- Pasture cropping is best suited to situations where growing season rainfall (as opposed to stored soil moisture) is the major driver of grain yield and subtropical grass growth in winter and spring can be arrested.
- When cropping kikuyu paddocks, suppress the grass before the growing season using glyphosate.
- Research has demonstrated that kikuyu will recover after one year of cropping and producers have observed recovery after two years of cropping.

Pasture cropping has considerable potential to improve yield in many parts of WA. It involves sowing winter grain crops (e.g. canola, wheat) into established perennial pastures. In the case of subtropical grasses on the south coast, this involves growing a crop in an established kikuyu pasture. Note that pasture cropping with panic grass has been successful in the Northern Agricultural Region and is likely to work equally well on the south coast.

While the aim of pasture cropping is a higher combined yield overall, in practice, kikuyu grass can rob the grain crop of valuable moisture by drying soil profiles in autumn, particularly in rainfall environments that receive <500mm annually. To prevent large reductions in grain yield, producers suppress kikuyu before the season break using glyphosate (~2L/ha depending on how active the kikuyu is) and this allows more of the autumn rain to be available to the emerging crop.

Trials in Esperance over several years (Figure 17) have shown that the most effective suppression of kikuyu for cropping occurs when high rates of herbicide or a double-knock are used in April or May. Only the 3L/ha of glyphosate in April and May and the double-knock of paraquat around 2L/ha in April followed by a second application of glyphosate at 2L/ha in May was able to significantly reduce kikuyu density in March the following year. Of these three, the double-knock of paraquat/glyphosate was the most effective, reducing the kikuyu ground cover in March from 35% in the control to 5%.

Pasture cropping with subtropical grasses allows producers to crop marginal soils, particularly the poorer sandplain soils that would otherwise not grow a crop without considerable risk. Potential advantages include improved profitability, control of summer weeds, growing feed grain for use on-farm, increased business flexibility and the ability to stabilise erosion-prone cropping paddocks.

Canola crop following kikuyu pasture near Bremer Bay

However, crops can be unprofitable in dry years due to competition for moisture and generally because of the low yielding soils on which kikuyu is typically grown.

In a trial undertaken in 1999 at Manypeaks, canola following kikuyu pasture yielded the same as that following annual pasture (Table 2). In this case, the producer suppressed kikuyu with herbicides and cultivated.

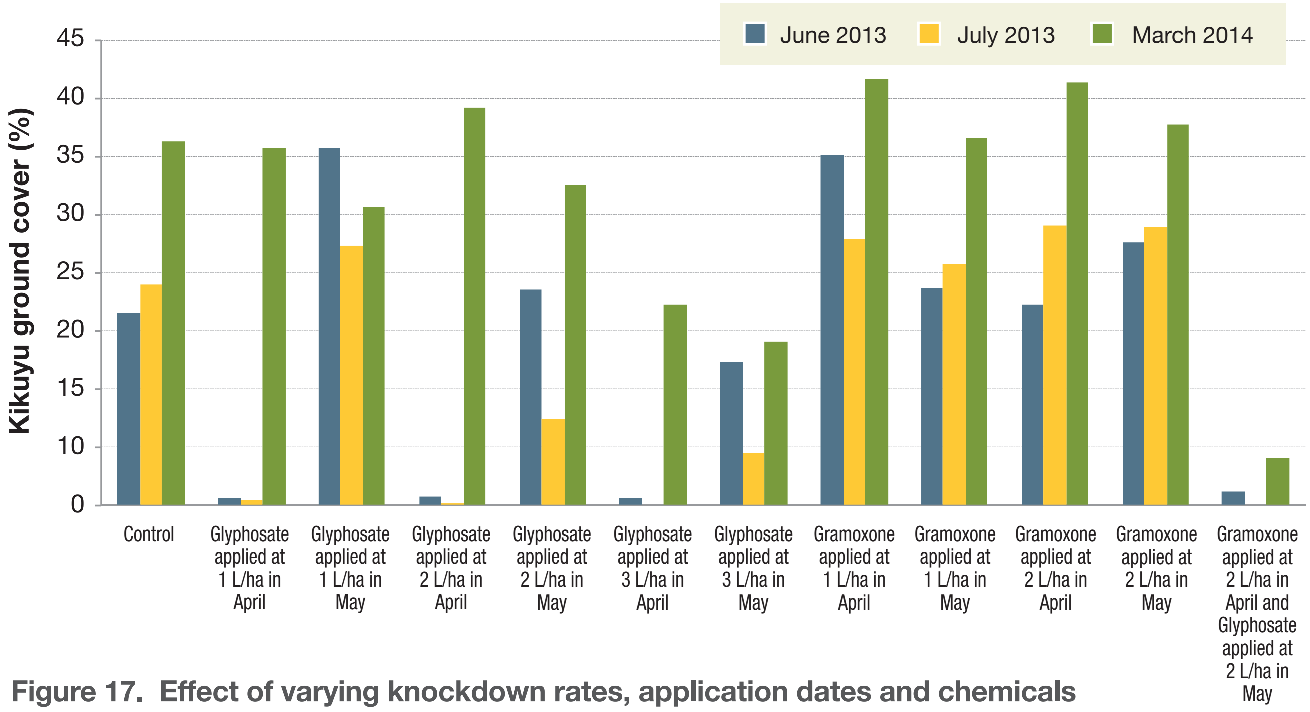


Figure 17. Effect of varying knockdown rates, application dates and chemicals on kikuyu percentage ground cover in Esperance. (All chemicals applied in 2013; measurement dates in legend)

Table 2. Canola plant counts, yield, grain protein and grain oil content following either annual or kikuyu pasture at Manypeaks, WA, in 1999. (Note: Numbers with different letters denote significant difference at P <0.05)

Treatment	Canola plant counts per m^2	Yield (tonnes/ha)	Grain protein (%)	Grain oil content (%)
Annual pasture	112[a]	2.46[a]	19.1[a]	43.5[a]
Kikuyu pasture	110[a]	2.32[a]	18.7[a]	44.3[b]

The site was previously a replicated pasture trial that enabled us to apply statistical analysis to show that there was no significant difference in yield or grain protein but that oil content for canola following kikuyu was significantly higher (Table 2). Before cropping, we had measured the percentage ground cover of the kikuyu treatments in March 1997, recording an average of 81%. In January 2000, following cropping, the percentage ground cover was 67% but had risen to 87% by May 2000, demonstrating kikuyu's ability to reestablish rapidly following a crop, particularly in this case with the occurrence of summer rain.

The 'Farmer case studies' section (see page 46) presents recent pasture cropping experiences reported by producers on the south coast.

Analyses of pasture cropping at a number of locations found that at Jerdacuttup, barley and wheat following a panic grass pasture recorded an average yield penalty of 12% and 16% (based on modelling over a 50-year simulation). Overall, the study concluded that pasture cropping was best suited to situations where growing season rainfall (as opposed to stored soil moisture) is the major driver of grain yield and subtropical grass growth can be arrested in winter and spring by low temperatures and suppression with herbicides before or at crop sowing.

An evaluation of the profitability of adopting subtropical grasses and pasture cropping in the central Wheatbelt concluded that the combined strategies typically increased farm profitability for meat-dominant enterprises by around 10%. However, subtropical grass and pasture cropping tended to be more valuable with less cropping, which suggests that increases for the south coast could be higher than 10%. Furthermore, pasture cropping was more profitable for meat-dominant sheep systems compared to wool. The study found that profit increases were most influenced by soil types on the farm, enterprise choice, forage quality of the subtropical grass, and the level of out-of-season production.

Research has demonstrated that kikuyu will recover after one year of cropping and producers have observed recovery after two years of cropping. It regenerates from seed and surviving rhizomes but the greater the suppression, the longer the recovery time.

Further reading

- GRDC, *Grain and Graze* website, viewed 1 August 2017. Search 'pasture cropping'.
  www.grainandgraze3.com.au/index.php

RIGHT: Kikuyu regenerating under a canola crop, which should be avoided

7. Farmer case studies

Case study 1.
Establishing panic grass

Producers: Percy, Susan and Richard Surridge
Property: 'Morande Park'
Location: Narrikup
Property size: 300ha
Arable area: 244ha pasture
Pasture area: 80% perennial pasture, 20% annual-based pasture
Livestock enterprise: Self-replacing Red Angus cattle
Livestock numbers: 300 head
Annual rainfall: 650–700mm

Percy and Richard Surridge know the benefits of perennials for their commercial beef-farming enterprise. Typical of the district, their property is dominated by kikuyu-based pastures. Percy has also tried Rhodes grass but it failed to persist.

Always willing to try promising new perennials, Percy heard about panic grass and attended a field day at Wellstead in 2012 to learn more. In late spring, he sowed 9ha of panic grass (cultivar Gatton) following a silage cut. However, it failed to establish due to competition from weeds. Percy tried again the next year. He was advised not to follow silage but set the paddock up with a double knockdown in September.

Richard successfully sowed the panic grass in early October using a pasture drill, placing the seed to a depth of 5mm. An assessment of plant numbers on 19 December 2013 revealed around 20 plants per square metre (m^2). Subsequent plant counts on 4 February 2014, 13 May 2014 and 26 March 2015 found similar plant numbers,

Case studies

Inspecting panic grass pasture: from left, Richard Surridge, Eric Dobbe (DPIRD) and Percy Surridge

demonstrating that panic stands with the correct management such as rotational grazing can persist. Target plant density should be 8–10 plants/m² after the first summer but with narrow row spacing and good planting conditions, double the density was achieved.

Sowing panic grass

Area sown: 9ha

Paddock history: Long-term annual pasture with improved species ryegrass and serradella

Paddock preparation:

First knockdown: 6 Sept. 2013 with 1L/ha Glyphosate 570

Second knockdown: 27 Sept. 2013 with 2L/ha spray seed + 200ml/ha alpha-cypermethrin

Date of sowing: 5–7 October 2013

Species/Varieties: Panic grass cultivar Gatton (coated seed)

Seeding rate: 4kg/ha

Soil type: 10cm grey sand over ironstone

Soil moisture at seeding: Good

Sowing equipment: Pasture drill (front cutting discs, tynes and press wheels)

Row spacing: 165cm

Post-sowing applications (fertiliser, herbicide, insecticide)

December 2013	100ml of Garlon + 1kg of Atrazine 900 + 500 ml of 24D ester + 1% Uptake oil per ha	Applied to control nightshade, fleabane, milk thistle and paddy melon
June 2014	25g Broadstrike + 100g Diuron + 1% oil per ha	Applied to control double gee, Paterson's curse and capeweed. Used as it is soft on clover and serradella
June 2014	Super potash 10kg/ha	
May 2015	Super potash 10kg/ha	
May 2016	Super potash 10kg/ha	

When asked how panic fits into his farming system, Percy responded, “Gatton panic is a very prolific growing plant from spring to late autumn and provides our cows with green feed for say seven months. Also, we feed it off in winter as we usually have legumes growing in between the panic plants. We rotate our cattle (35 cows to a mob) for about seven days every 3–4 weeks, depending on summer rain. We find it is better to eat it down quite a lot; that way it doesn’t get too tufty. We did not graze it for the first nine months to allow the plant to anchor down and develop a good base.”

Recipe for success

- Effective weed control before sowing panic (panic seedlings are poor competitors).
- Sow into a moist soil profile (if it is a dry winter, think twice about sowing).
- Sow at the right time. Along the south coast of WA, the sowing window is 7 September to 15 October. The earlier, the better.
- Precise seeding depth of 5–10mm. Not deeper! Furrow sowing and press wheels work well on sandy soils.
- Post-germination weed control in the first summer. If summer weeds are present, controlling them will enhance panic plant survival.
- Don’t graze too early. Allow plants to develop a decent root system and be anchored down.

BELOW: Panic grass after summer rain in January 2016

Case study 2.

Improving winter feed content of subtropical pastures – a grower group demonstration

Grower group: Fitzgerald Biosphere Group (Jerramungup)
Producers: Adrian (Ross) and Rhonda Williams
Property: 'BETWS – Y – COED'
Location: Gairdner
Property size: 629ha
Cropping: 300ha
Pastures: 300ha annual and perennials
Livestock enterprise: Prime lamb
Annual rainfall: 450mm

The aim of this demonstration was to answer the following questions:

- What seeding method provided the best establishment of annual species into a long-term kikuyu stand?
- Would oats or serradella establish better into kikuyu?
- Would spraying a knockdown herbicide to supress kikuyu and soil disturbance increase recruitment of subterranean clover from the existing seedbank?

A 35ha kikuyu paddock on a duplex sandy gravel (pH ($CaCl_2$) 4.6, Colwell 14 parts per million) was chosen for the demonstration site. The paddock had been in pasture for the previous two years. An initial knockdown with 2.5L/ha glyphosate was applied in July 2014. Unfortunately, due to dry conditions and poor growth, the glyphosate was ineffective. A second knockdown was applied in August 2014, with 2L/ha of paraquat.

The demonstration was sown in August 2014 with an old seeding bar that was set up in the configurations shown in Figure 18 and the trial pattern sown three times over the paddock (Figure 19). Sowing rates were 8kg/ha French serradella cultivar Cadiz and 100kg/ha oats variety Kojonup.

RIGHT: Ross Williams

Knife points with double-disc openners and press wheels

Winged points with double-disc openners and press wheels

Winged points with press wheels

Knife points with press wheels

Double-disc openners and press wheels

Figure 18. Seeding bar configurations

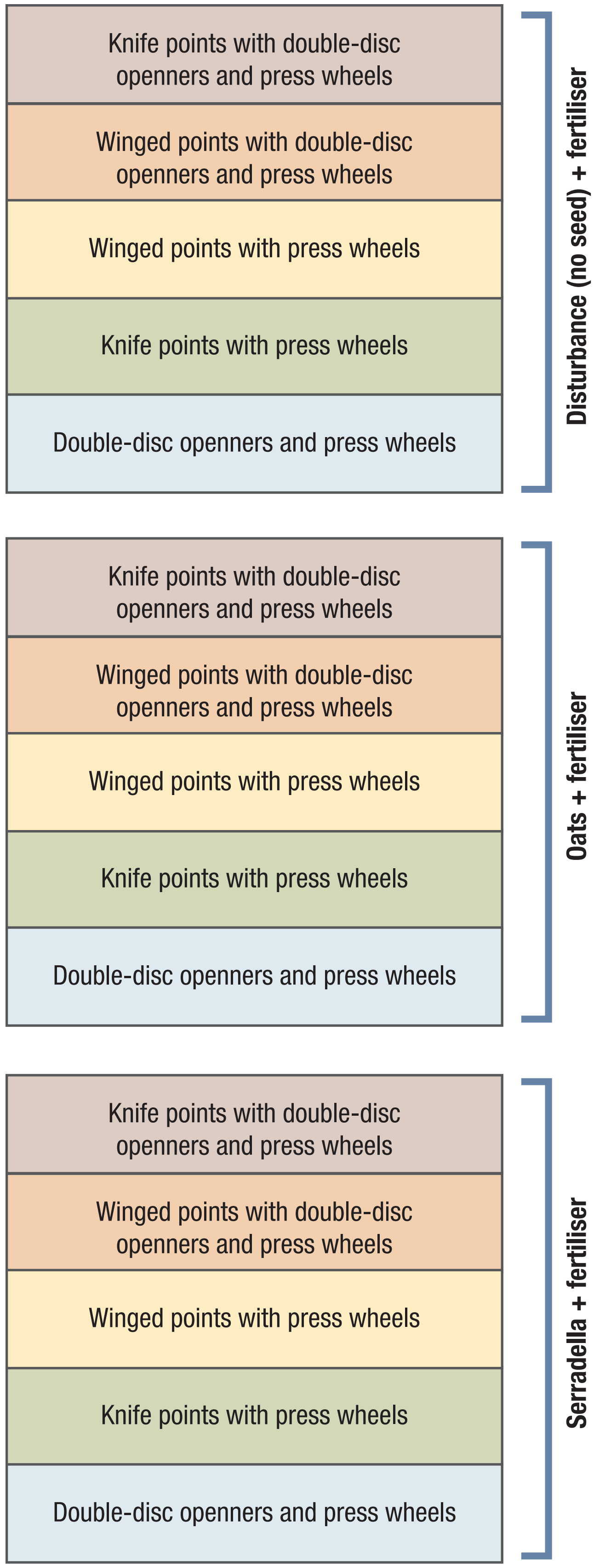


Figure 19. Trial layout

Table 3. Trial results

	Knife points with double disk openers and press wheels	Winged points with double disk openers and press wheels	Winged points with press wheels	Knife points with press wheels	Double disk openers with press wheels
Serradella (plant/m^2)	304	117	59	43	208
Oats (plant/m^2)	224	160	32	10	80

In both the oats and serradella sown treatments, knife points with double disk openers and press wheels provided the best seedling establishment. Below are the photos of the oat pasture establishment with each seeding system.

Knife points with double disk openers and press wheels

Plants per m^2 established = 224

Winged points with double disk openers and press wheels

Plants per m^2 established = 160

Winged points with press wheels

Plants per m^2 established = 32

Knife points with press wheels

Plants per m^2 established = 10

Double disk openers with press wheels

Plants per m^2 established = 80

The serradella pasture established a lot better than the oats. Photos below show the counts and seeding styles over the serradella plots.

Knife points with double disk openers and press wheels	Winged points with double disk openers and press wheels	Winged points with press wheels	Knife points with press wheels	Double disk openers with press wheels
Plants per m^2 established = 304	Plants per m^2 established = 117	Plants per m^2 established = 59	Plants per m^2 established = 43	Plants per m^2 established = 208

Knife points with double disk openers and press wheels	Winged points with double disk openers and press wheels	Winged points with press wheels	Knife points with press wheels	Double disk openers with press wheels

Soil disturbance did induce the germination of subterranean clover seed, which can be seen in the results where ground cover is equal to or more than seeding serradella over most seeding methods. The higher the tillage option, the more the soil dried out, causing lower germination. The photos above show the germination caused by different levels of soil disturbance.

Conclusion

A late break to the season and very dry summer meant it was hard to get an effective knockdown to work and establishing the pasture was difficult due to unseasonably dry conditions.

Ross said that although the zero seed option worked as well as the serradella in the 2014 season, this would probably not have been the outcome in a typical season. He commented he would not consider using a zero seed option again.

Case study 3.
Establishing serradella in kikuyu pasture

Producers: Alan and Bec Hoggart
Property: 'The Duke'
Location: Condiniup
Property size: 2500ha
Livestock enterprise: Prime lamb
Livestock numbers: 5600 Dorper/Wiltshire ewes
Pasture species: Subterranean clover, serradella annual ryegrass and kikuyu
Soil type: Black clay, sand over gravel to deep sand
Annual rainfall: 650mm

Alan and Bec Hoggart of 'The Duke', near Esperance, have been involved in a three-year MLA-funded legume trial with their local grower group, the Association for Sheep Husbandry, Excellence, Evaluation and Production (commonly known as ASHEEP) as part of the MLA's Producer Research Site program.

The ASHEEP group wanted to investigate using serradella in kikuyu pastures, given subclovers have been patchy over the past few years on the south coast due to red clover disease, which causes a reddening of the leaf and plant dieback.

The trial tested two varieties of serradella sown at different times of the year. Trial paddocks were prepared for legume sowing as follows:

- summer — kikuyu was heavily grazed and sprayed in early autumn
- autumn — kikuyu was heavily grazed until May and sprayed before sowing.

Legume sowing consisted of:

- summer — Margurita serradella pod at 25kg/ha and unscarified Bartolo bladder clover seed at 20kg/ha in February
- autumn — Santorini and Margurita serradella at 10kg/ha seed and Bartolo bladder clover at 10kg/ha seed in May.

The legume seeds/pods were sown within 1cm of the surface, with rows 30cm apart.

Top performer

Of the two varieties of serradella, Alan found Santorini performed the best on his property.

"In my experience, Santorini has more tolerance to grazing by sheep and has added value to our lower grade pastures. Santorini gets going a lot quicker without competition, but it will establish in a kikuyu pasture with the right management. Once established, it persists without too much intervention in a rotational grazing operation."

Sowing time

Although other producers on the south coast have had success with summer sowing, Alan said it was far more suited to cropping enterprises.

"Our property has areas of light, sandy soil prone to erosion, so we don't crop. We needed to improve our lighter soil pastures with varieties that persist with minimal intervention.

"We had average rainfalls of 540mm over the three years of the trial, and found planting into existing pasture in summer didn't work for us because the kikuyu takes too much moisture away from the legumes.

"Sowing in autumn gave the seedlings more access to moisture because of increased winter rain and decreased kikuyu activity."

Next steps

With the trial completed, Alan said he and Bec would continue with autumn-sown serradella because the seedlings had a better chance of establishing, and once established, the legumes worked well in kikuyu pastures.

Successful establishment of serradella in a kikuyu pasture in Esperance

This case study was written and provided by Meat & Livestock Australia.

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Case study 4.

Pasture cropping into kikuyu, herbicide use and regrowth of pastures

Producers: Ken and Jan Reddington, son Paul and his wife Alice

Location: Bremer Bay

Property size: 2000ha

Enterprise mix: 80% livestock, 20% cropping (some for hay), prime lamb, fine wool, and cattle for vealer production. Tactical cropping.

Soil type: Sandy duplex

Annual rainfall: 520mm, with 25–30% as summer rainfall

Ken Reddington and son Paul crop canola followed by oats or triticale for hay on their Bremer Bay farm. The south coast sandplain is at high risk of wind erosion. Kikuyu pastures, in areas with suitable rainfall, help stabilise sandy soils, provide out-of-season feed and fill the autumn feed gap.

Although kikuyu is a good option for sandy soils, farmers have reported reduced productivity because of thatching, decreasing amounts of subterranean clover and increasing silver grass in older kikuyu stands.

Ken and Paul's solution was to open up the thatch in their 20-year-old kikuyu paddocks by mechanically working them up. After observing that this caused the kikuyu pasture to respond by returning with vigour, Paul suggested that cropping with canola into the kikuyu paddocks would rejuvenate the kikuyu. The solution was to give pasture cropping a go.

The Reddingtons found that after the cropping phase, and provided there was spring and summer rainfall, kikuyu responded with good regrowth. The subterranean clover also returned with winter rain and the silver grass disappeared, providing much higher quality pasture.

In addition, canola's long taproot might help aerate the soil and the rejuvenated kikuyu, which was initially sparse, provided room for subterranean clover to establish. As a result, over the past four years, they have now cropped between 75 and 150ha of kikuyu per year.

Ken and Paul's approach in cropping into perennials is to keep the system low cost, low input. They first tried one year of cropping and then let the kikuyu regrow, but they found that two years of cropping thinned out the kikuyu more effectively and was important in removing the silver grass. They now crop the first year with canola and follow with a hay crop of triticale or oats. The system has also assisted with weed control where silver grass and geranium are their main weed problems. While two years of cropping was effective in controlling the silver grass, they have had to use 2,4-D on geranium, which grow in gaps between the kikuyu. So far, they have been in front financially because of the return on the crops and the improvement in the pasture phase.

In future, Ken and Paul plan to crop each kikuyu paddock once every five years or so in rotation. Nevertheless, they also see the advantage in keeping the system flexible and being able to respond to the season. In a good year, they might put extra paddocks into crop.

Kikuyu growing in crop stubble from the previous year

If the season shapes up to be a dry one, they will crop less and use fewer inputs.

The amount of herbicide required to suppress the kikuyu for cropping depends on seasonal conditions. The Reddingtons generally use a double knockdown, with 540g/L glyphosate at 2L/ha, followed up with Sprayseed® at 1.5L/ha. With an early break, the glyphosate effectively suppresses all the kikuyu. They have used atrazine at 2kg/ha post-seeding to control silver grass in the canola crop but in future will split the atrazine into two applications of 1kg/ha, one pre-emergent and one six weeks later for better control.

Ken and Paul use a disc coulter in front of a double-disc V-shaped opener with press wheels behind. The discs cut through the kikuyu and release the nitrogen bound up in the thatch. They seed triazine-tolerant (TT) canola at 3.5–4kg/ha and apply 100kg/ha Agras at seeding in two applications, followed by one or two applications of up to 75kg/ha of a fertiliser containing 33% N and 11% S, depending on the season. They use alpha-cypermethrin at 400ml/ha and 150ml/ha of Le-mat to control mites in the canola. They use 80kg/ha Agras in seeding the following cereal crop.

Regrowth of kikuyu after cropping has been good, particularly in seasons with summer rain. When they cropped for only a single year, the kikuyu came back too strongly to allow good subterranean clover recruitment. The Reddingtons get good kikuyu regrowth even after two successive years of cropping because they average 25–30% of their annual rainfall in summer. Experience is showing they can use a lower rate of glyphosate in the second year because there is less kikuyu.

The south coast, like many regions in Australia, has a variable climate and the Reddingtons know that flexibility in adapting to seasonal conditions is the key to cropping into perennials. Paul is keen to trial other perennials to complement the system and increase flexibility.

After four years of cropping into kikuyu, Paul said, "We are still feeling our way with the system because everything depends on the particular season."

This case study was provided by South Coast NRM through their Climate Action on Farms project

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SOUTHCOAST NATURAL RESOURCE MANAGEMENT INC

Regional Landcare Facilitator

Appendices

Appendix 1.

Sheep costs and prices used in economic analysis

Costs

Ewe shearing		$7.32/head
Shearing lambs		$7.32/head
Ewe husbandry		$5.41/head
Lamb husbandry		$4.34/head
Ewe replacement		$136.00/head
Rams		$1000.00/head
Sheep sales commission		9.7%
Sheep sales cost		$2.10/head
Pasture cost		$80.00/ha
Supplement costs	Lupins	$350.00/t
	Pellets	$390.00/t

Prices

Wool prices for ewes	19 micron	1290c/kg
	20 micron	1183c/kg
	21 micron	1155c/kg
	22 micron	1126c/kg
	Av. fleece price	90%
	Wool commission	7.3%
Ewe sales	Base price	261c/kg
	Dressing percentage	42%
	Skin price	$0.00/head
Ewe lamb sales	<18kg	447c/kg
	>18kg	493c/kg
	Dressing percentage	45%
	Skin price	$0.00/head
Wether lamb sales	<18kg	447c/kg
	>18kg	493c/kg
	Dressing percentage	45%
	Skin price	$0.00/head

Appendix 2.

Annual pasture legume characteristics

Table 1. General characteristics of pasture legumes suited to subtropical grass pastures on the south coast of WA

Common name	Botanical name including subspecies	Hardseed[1]	Rainfall (mm)	Soil type	pH_{ca} range	Water- logging tolerance	Inoculant group	Sowing time[2]	Sowing rate (kg/ha) when sown alone
Major									
Subterranean clover	*Trifolium subterraneum ssp. subterraneum*	VL–H	275–1200	Well drained sandy-loam to loamy clay soils	4.5–6.5	P	C	Autumn	5–15
	Trifolium subterraneum ssp. yanninicum	VL–M	425–1200	Poorly drained sandy loam to clay soils	4.5–6.5	G	C	Autumn	5–15
Yellow serradella	*Ornithopus compressus*	VH	250–700	Deep, well-drained sands and sandy loam soils	4.0–6.5	P	G/S	Pod summer; Seed autumn	Pod 10–20; Seed 5–7
French serradella	*Ornithopus sativus*	Nil–H	250–500	Deep well-drained sands and sandy loam soils	4.0–6.5	P	G/S	Pod summer; Seed autumn	Pod 10–20; Seed 5–8
Minor									
Woolly pod vetch	*Vicia villosa*	L	>425	Medium and heavier soils of moderate fertility	5.0–7.0	P	E/F	Autumn	25–35
Common vetch	*Vicia sativa*	Nil	300–700	Sandy loams to clays of moderate fertility	5.0–7.0	P	E/F	Autumn	30–40
Burr medic	*Medicago polymorpha*	VH	250–600	Sandy loams to clays of moderate fertility	4.8–8.5	L	AM	Autumn	6–10
Balansa clover	*Trifolium michelianum*	L–M	350–1200	Loamy sands to clay soils	4.5–8.5	G	C	Autumn	2–5

[1] Note that in some species the level of hard seed can vary considerably between cultivars.
[2] Autumn sowing is after the break of season.

Legend
General scale: VH = Very High; H = High; G = Good; M = Moderate; L = Low; VL = Very Low; P = Poor

Appendices

Further reading

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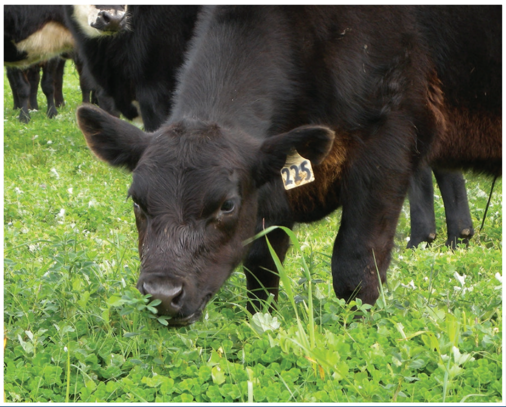

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