Chapter 5
Sub-tropical grasses

Sub-tropical grasses .................................................. 124
Geoff Moore

Soil-climate requirements .................................. 125

Which species to grow? ........................................ 127

Establishment with Phil Barrett-Lennard .......... 129

Animal production ............................................. 134

Balanced pasture .................................................. 135

5.1 Bambatsi panic (Panicum coloratum) .......... 138

5.2 Consol lovegrass
   (Eragrostis curvula type conferta) ................. 140

5.3 Digit grass (Digitaria eriantha) ................. 142

5.4 Kikuyu (Pennisetum clandestinum) ................. 144

5.5 Panic grasses (Megathyrsus maximus) .......... 148

5.6 Rhodes grass (Chloris gayana) ................. 150

5.7 Setaria (Setaria sphacelata complex) ................. 153

5.8 Signal grass (Urochloa decumbens) ................. 156

5.9 Other warm season grasses: Buffel grass,
   Couch grass, Elephant grass, Paspalum,
   Vetiver grass .............................................. 158

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Sub-tropical grasses

Geoff Moore

- spectacular production on summer-moist areas
- highly responsive to summer-autumn rainfall
- tolerant of high temperatures
- adapted to sandy soils that are marginal for cropping
- feed quality depends on grazing management and nitrogen nutrition
- most species require rotational grazing to persist
- establishment can be difficult
- susceptible to frost damage
- can persist under stressful conditions (drought, cold, low fertility) but productivity is likely to be low.

There is increasing interest in sub-tropical grasses to:
- increase production from land with a low productivity
- reduce supplementary feeding in autumn and to allow grazing on annual pastures to be deferred after the break of season until they are well established (e.g. feed-on-offer is 500-800 kg of DM/ha)
- integrate with other annual and perennial pasture types to achieve year-round green feed. Sub-tropical grasses with a high plant density can be expected to produce in the order of 20-30 kg DM/ha/mm of rainfall over the summer-early autumn period (assuming rainfall events >20 mm over seven days)
- increase water use to reduce the spread of salinity
- reduce the risk of wind erosion, especially on the south coast
- enable stock to be turned off all-year-round to meet market requirements.

Sub-tropical grasses (also called summer-active, warm season or C4 grasses) are not new to Western Australia. Kikuyu and paspalum have been grown in high rainfall districts, on the Swan Coastal Plain and on the south coast for many years. Buffel grass was observed growing on the north-west coast of WA in the late 19th century and was subsequently widely sown by pastoralists. However there has been a marked increase in the use of sub-tropical grasses in the last 5-10 years.

In 1990 two series of trials commenced to test alternative perennial pastures in the West Midlands, where farmers were struggling to adapt wheatbelt farming systems to the highly leached sands. Jesse Skoss, a private agronomist, tested several sub-tropical grasses and legumes on behalf of local farmers. At the same time, the Department of Agriculture evaluated a range of annual and perennial pasture options for sandy soils. The temperate perennial grasses (phalaris, tall fescue, cocksfoot) failed to persist over summer, but the sub-tropical grasses persisted and showed promise. These trials were not continued but a group of innovative farmers and Tim Wiley, a district adviser (DAWA), continued with on-farm testing and tackled establishment and management on a commercial scale.
Sub-tropical grasses

C4 photosynthetic pathway

The sub-tropical grasses use the C4 photosynthetic pathway whereas most plants assimilate carbon dioxide (CO$_2$) via the C3 photosynthetic pathway. The names are simply derived from the number of carbon atoms in the first product of photosynthesis (C4 = 4 carbon compound, C3 = 3 carbon compound). Photosynthesis is the process by which plants take in CO$_2$ from the atmosphere through open pores (stomata) in the leaves (and stems) which is then combined with water (H$_2$O) to produce sugar and oxygen (O$_2$) using the sun's energy.

The C4 plants have some important advantages over C3 plants in hot, dry conditions. They are more water and nitrogen efficient, but require more energy (light) as there is an additional step in the photosynthetic pathway. The C4 plants only need to keep their stomata open for short periods, so they lose much less water (transpiration) for the same amount of CO$_2$ fixed by photosynthesis. This is a significant advantage under hot, high light intensity, moisture-limiting conditions, which aptly describe the conditions in WA in summer and early autumn.

The C3 plants have their stomata open for longer periods, so transpire more water. When it is hot and dry, the stomata close to conserve water but this slows photosynthesis (growth). Also, at high temperatures (>30°C) C3 plants can photo-respire whereby respiration occurs instead of photosynthesis and previously fixed CO$_2$ is released instead of O$_2$. Consequently, under hot, moisture-limiting conditions the C3 plants revert to other drought survival mechanisms like leaf senescence and dormancy well before the C4 grasses use these adaptations.

On the other hand, C3 plants are more efficient than C4 plants under cool, moist conditions and at lower light intensities. The temperate pasture species are all C3 plants and they grow actively in winter when the C4 plants are dormant or only able to grow slowly.

Soil–climate requirements

Sub-tropical grasses are generally grown as permanent pastures on land that is non-arable or where the return from annual crops is marginal or unprofitable. They are occasionally used in rotation with crops, but perennial or annual legumes are generally preferred because of their nitrogen benefits to the following crop. The climatic factors affecting their growth and persistence are different to many of the temperate species as they predominantly grow outside the May-October growing season for annual crops and pastures. The key climatic features affecting the sub-tropical grasses are summarised in Table 5.1.

Sub-tropical grasses are similar to other crops and pastures in that the highest production under ideal conditions will generally be from soils with good physical and chemical properties, such as fertile, deep loamy soils. These soils are also the most productive cropping soils and as a result are usually used in an intensive crop rotation.
The sub-tropical grasses mainly grow outside the normal May to October growing season of annual crops and pastures. The grasses can grow slowly in early winter (June) in coastal districts and slowly right through winter in the northern agricultural region, however in most areas they are dormant over winter. They start growing in spring as the temperature increases. They respond rapidly to rain when the temperatures are warm to hot.

As a result, sub-tropical grasses largely rely on moisture outside the normal growing season. In regions with low rainfall outside the growing season, production will be low in many years. The exception is sites with extended subsoil moisture into late spring, or a fresh watertable within the root zone.

Frequency and severity of frosts

There is variation in frost tolerance between species. Sensitive plants can be killed. With other species, heavy frosts can kill the above-ground parts of the plant, but the plant will regrow when the temperature increases. Some species will tolerate mild frosts and retain green leaf.

The sub-tropical season grasses are grown successfully in central Queensland and northern New South Wales, areas that experience a higher frequency and severity of frosts than WA. Areas subject to frosts will not preclude growing sub-tropical grasses, but they will influence the selection of species and there may be minimal growth from the start to the end of the frost period.

‘Cold zone’

There is growing evidence that persistence of sub-tropical grasses over winter is adversely affected in a ‘cold zone’ which extends from approximately Northam in the north to Manjimup in the south and to the eastern boundary of the agricultural area. This ‘cold zone’ has been spatially defined from maps of July-August mean minimum temperature and frost frequency (Figure 5.1).

The poor persistence seems to be due to combination of cold, wet soils and frosts. Typically there is a high mortality of bunch grasses with 70-100% of the plants dying over winter. The grasses are burnt off by the first frosts in winter, but instead of regrowing in spring they have died over winter. Species affected include setaria, panic, bambatsi panic, signal grass and digit grass.

On the other hand, grasses with rhizomes, kikuyu, paspalum, couch grass plus African lovegrass, all show good winter survival. The persistence of Rhodes grass varied from fair to poor, with diploid varieties showing better persistence than Callide (tetraploid).

Temperatures in late winter and early spring

The sub-tropical grasses start growing actively between late winter and mid-spring depending upon the temperature. Mild to warm conditions in early to mid-spring enable the sub-tropical grasses to grow actively in the growing season and this lessens their reliance on rainfall outside the May-October growing season. This is the case in the northern agricultural region, where the sub-tropical grasses grow slowly over winter and actively in spring.

With most species there is a marked decrease in growth below 20°C with minimal growth below 15°C. Species with better growth at 15-18°C include setaria, Rhodes grass and kikuyu. Low temperatures at night can have a marked effect on growth even when the day temperatures are mild to warm. For instance, with day temperatures of 20°C, the growth of Rhodes grass was reduced by 60% when night temperatures were reduced from 8 to 4°C.165

![The relative cold tolerance of (a) signal grass, (b) panic grass, and (c) Rhodes grass](image)
However, there are a number of land management units (soil types) with the potential for increased production from sub-tropical grasses including:

- summer-moist sites – with a shallow non-saline watertable
- winter waterlogged sites that are too wet for cropping – with a perched watertable for extended periods from winter through to mid-spring
- deep leached sands and gravelly sands that are marginal for cropping
- moderately deep sandy duplex soils
- marginally saline land with a watertable at 1.5-2.5 m, where sub-tropical grasses could be sown between rows of saltbush. The saltbush acts as a water pump to keep the watertable at depth so that salt does not accumulate on the surface through capillary rise
- highly acidic sandy soils.

Shallow soils have a low potential for perennial pastures due to their restricted soil depth.

**Which species to grow?**

Most of the sub-tropical grasses are native to summer rainfall regions in southern and central Africa or South America. The commercial varieties currently available were developed for sub-tropical and tropical environments in eastern Australia, which have a summer dominant rainfall pattern. These grasses can be grown successfully in a winter-dominant rainfall environment like WA due to their ability to persist though dry periods and because of their cold and frost tolerance. In Africa many summer rainfall regions have either extended dry periods or the summer rainfall is highly variable, so the grasses from these regions have some drought tolerance.

Like most plants, sub-tropical grasses prefer certain soils and have varying tolerances of waterlogging, inundation, soil acidity, soil salinity and low fertility.

The soil type recommendations developed for the eastern States of Australia are not directly transferable to WA. Some species have been grown successfully in WA on soils that would be considered marginal or unsuitable in Queensland, however other species have specific soil requirements (e.g. bambatsi panic).

In WA we are still determining where many of the sub-tropical grasses are well adapted, as many have only been grown in a limited number of field trials and/or farmer paddocks. Table 5.2 attempts to summarise the soil adaptation for the main species currently grown commercially or with potential for WA. It has been compiled from preliminary trial results and observations in WA and will continue to be a work in progress.
### Table 5.2 Potential for sub-tropical grasses on the main land management units in WA (see key below)

<table>
<thead>
<tr>
<th>Land management unit</th>
<th>Bambatsi panic</th>
<th>Digit grass</th>
<th>Kikuyu</th>
<th>Lovegrass (Consol)</th>
<th>Panic grasses</th>
<th>Paspalum grasses</th>
<th>Rhodes grass</th>
<th>Setaria</th>
<th>Signal grass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum rainfall* (mm)</td>
<td>&gt;375</td>
<td>&gt;450</td>
<td>&gt;500</td>
<td>&gt;375</td>
<td>&gt;475</td>
<td>&gt;550</td>
<td>&gt;425</td>
<td>&gt;550</td>
<td>&gt;500</td>
</tr>
<tr>
<td>Minimum rainfall* (mm) (south coast)</td>
<td>&gt;325</td>
<td>&gt;400</td>
<td>&gt;400</td>
<td>&gt;350</td>
<td>&gt;400</td>
<td>&gt;475</td>
<td>&gt;400</td>
<td>&gt;475</td>
<td>&gt;450</td>
</tr>
<tr>
<td>Summer moist soils (non-saline)</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Winter waterlogged sandy soils</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Mildly saline soils</td>
<td>✔️</td>
<td>✗</td>
<td>✔️</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Saline soils</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Loamy soils (mod. well to well drained)</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<td>✔️</td>
<td>✔️</td>
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<tr>
<td>Clay soils (imperfectly to well drained)</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Shallow sand (&lt;0.3 m) over gravel or clay</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<td>✔️</td>
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<td>✔️</td>
</tr>
<tr>
<td>Moderately deep sand over clay or gravel</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<td>✔️</td>
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<td>✔️</td>
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<tr>
<td>Deep coloured sands</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Deep leached sands</td>
<td>✗</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Deep acid sand (pH Ca 4.0-4.3)</td>
<td>✗</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✔️</td>
</tr>
</tbody>
</table>

* Except for moisture gaining sites

**Key:**
- ✔️️️️️ = well adapted
- ✔️️️️ = adapted
- ✔️️ = will grow, but may have poor persistence or productivity
- ✗ = not suited.

**Confidence level for Western Australian conditions**

- Low – limited testing or grower experience
- Moderate – some testing or grower experience
- High – extensively grown or tested
Establishment
With Phil Barrett-Lennard

Sub-tropical grasses require soil temperatures greater than 15-18°C to germinate, so the options are to sow in either autumn or spring.

Autumn sowing is risky as annual volunteer weeds will germinate over an extended period and compete strongly with the perennial grasses, which then have to persist through winter as small plants. However, there are examples where spring-sown grasses that have failed to germinate due to the dry seasonal conditions have subsequently germinated following rain in March-April and established well.

The preferred time to sow sub-tropical grasses is in late winter to early to mid-spring when the soil temperature is favourable.

The sowing window for sub-tropical grasses depends on the region. Figures 5.2a-c show the mean monthly temperatures for August, September and October, which is a surrogate for soil temperature. The soil temperature is also affected by the colour of the surface soil, with dark soils absorbing more heat. In addition, wet soils take much longer to warm up (i.e. up to six weeks longer to reach the critical temperature for sowing), because of water evaporating from the surface.

In general, seeding should be as early as possible in each region to maximise the likelihood of good follow-up rain. The approximate ‘sowing window’ for each region is summarised in Figure 5.3.

All areas have adequate soil temperatures sometime between late August and early October for the germination of sub-tropical grasses. However, in low rainfall districts the likelihood of adequate rain after seeding decreases, so there is a higher risk of poor or failed establishment.

Figure 5.2 The mean monthly temperature for (a) August, (b) September and (c) October (D. van Gool, DAFWA using BoM Base Climate data)
Many commercial sowings of sub-tropical grasses result in about 1 plant/m² per kilogram of seed per hectare. This is an unsatisfactory result as it correlates to a strike rate of only 1-2%, assuming seed viability of 50%. Failure to achieve complete weed control, poor control of seeding depth and not overcoming non-wetting sands seem to be the primary reasons for poor or failed establishment.

Seven key factors for successful establishment are listed below. If these are followed, then a greatly improved strike rate should be achieved and the potential production from the perennial pasture will not be compromised.

**Key factors for successful establishment**

a) Total weed control during the establishment phase

Total weed control is essential as the sub-tropical grasses have low seedling vigour and compete poorly with weeds. For example, typically there is very poor or failed establishment in areas that are missed by the boomspray.

Weed control at sites with potential problem weeds should commence in the year before seeding. Some of the problem weeds that adversely affect the establishment of sub-tropical grasses are listed in Table 5.3.

At most sites a double knockdown is required to give complete weed control, although under certain conditions a single knockdown with glyphosate will give good results.

**Table 5.3 Problem weeds that adversely affect the establishment of sub-tropical grasses**

<table>
<thead>
<tr>
<th>Weeds germinating in spring</th>
<th>Cool season weeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghan melon (<em>Citrullus lanatus</em>)</td>
<td>Annual ryegrass (<em>Lolium rigidum</em>)</td>
</tr>
<tr>
<td>Fleabane (<em>Conyza spp.</em>)</td>
<td>Capeweed (<em>Arctotheca calendula</em>)</td>
</tr>
<tr>
<td>Ice plant (<em>Mesembryanthemum crystallinum</em>)</td>
<td>Silver grass (<em>Vulpia spp.</em>)</td>
</tr>
<tr>
<td>Mint weed (<em>Salvia reflexa</em>)</td>
<td>Subterranean clover (<em>Trifolium subterraneum</em>)</td>
</tr>
<tr>
<td>Prickly paddy melon (<em>Cucumis myriocarpus</em>)</td>
<td>Wild radish (<em>Raphanus raphanistrum</em>)</td>
</tr>
<tr>
<td>Roly-poly (<em>Salsola kali</em>)</td>
<td></td>
</tr>
<tr>
<td>Wireweed (<em>Polygonum arenastrum</em>)</td>
<td></td>
</tr>
</tbody>
</table>
Double knockdown strategy:
- Graze the paddock heavily in early winter and then spell it for one to two weeks before the first knockdown to allow new leaf growth for chemical uptake.
- Apply glyphosate (usually 1.5-2 L/ha) as the first knockdown about six weeks before seeding to allow time for any biomass to break down. Consider adding a spike if large broadleaved weeds are present. Avoid using herbicides with a soil residual effect like Atrazine as these will affect some sub-tropical grasses.
- A second knockdown is usually required a few days before seeding. This will kill any newly germinated seedlings plus weeds that are difficult to control such as silver grass and large broad-leaf weeds that have recovered from the first spray. Plants that are stressed when the first knockdown is applied are also likely to recover. The second knockdown should also be glyphosate. SpraySeed® is not recommended when the second knockdown is more than 10 days after the first. A broad spectrum systemic insecticide can be applied at seeding for short-term insurance.

b) Selecting appropriate species for the environment (soils, climate)
To select the most appropriate species or mix of species for a site, use the summary in Table 5.2 plus the descriptions of individual species together with results from local trials and on-farm test strips. When using a ‘pasture mix’ ensure that all of the species in the mix are adapted to the soil and climatic conditions to avoid wasting seed.

When sowing mixtures, pasture composition appears to be affected by the sowing depth and the soil moisture conditions during establishment. If the seed is sown on the surface and rolled (shallow sowing <5 mm) or the soil moisture after seeding is marginal, then these conditions appear to favour Rhodes grass, while a slightly deeper seeding depth (5-10 mm) tends to favour the bunch grasses. A number of sub-tropical grasses display a secondary dormancy (hydropedesis) if they begin to germinate and the soil temperature and moisture conditions are unfavourable. However, this is not the case with Rhodes grass, so under marginal conditions it will be the first species to germinate.

It is preferable to sow a seed mix that contains both bunch grasses and stoloniferous (spreading) grasses in alternate rows, although this is not always practical.

In some instances there may not be any sub-tropical grasses well adapted to the soils and climate at a site. Investigate the use of alternative perennial pasture types to meet the identified need (e.g. reduce supplementary feeding in autumn) rather than use poorly adapted sub-tropical grasses.

c) Good quality seed
Sub-tropical grass seed can vary widely in quality (germination rate, purity, weed seeds). Freshly harvested seed of some species has a low germination due to post-harvest seed dormancy, so do not sow freshly harvested seed of these species. Use good quality seed with a known germination, which is free of weed seeds.

The germination of sub-tropical grasses can vary from as low as 10% to more than 70% – 40% germination is considered quite acceptable, while 70% is excellent. When purchasing seed compare the price per kilogram of viable seed. The seeding rate should be adjusted if the germination is less than 50% (i.e. if 25% germination then double the seeding rate).

Most commercial sub-tropical grass seed is currently produced in eastern Australia and imported into WA. By law all seed entering the State is required to pass through WAQIS before it is released. This ensures that (i) the species is permitted in WA and (ii) it does not contain any prohibited weed seeds. There are some serious weeds in eastern Australia that are not present in WA, so ensure these protocols are always followed.

d) Soil temperature and moisture
A combination of soil temperature (>15-18°C) and follow-up rain is required for sub-tropical grass seed to germinate. As a guide the grasses will germinate when the soil temperature at 9:00 am is more than 15-18°C for several consecutive days. The soil temperature can be measured or estimated from the air temperature.
Sub-tropical grasses have been established successfully with only 25 mm of rain after seeding in spring, provided there is stored moisture in the soil profile and excellent weed control. However, for the seedlings to access the subsoil moisture there needs to be a continuous band of moisture from the topsoil down to the subsoil. Provided the plants are well established by the start of summer, there is usually a good survival rate even through a dry summer.

With poor or failed establishment there is often poor seedling emergence in spring or the grasses are still small at the start of summer making them very susceptible to drought stress. If there are dry conditions in early to mid-summer many of these plants will not survive.

e) Seeding method
Sub-tropical grasses have small seeds (400,000 to 4 million/kg), so shallow sowing at 5-10 mm with good seed-soil contact is essential. The seeding requirements seem straightforward, but many commercial sowings achieve only poor to fair establishment. A wide range of seeding equipment can be used, but it should be set-up carefully to achieve accurate seed placement and good seed-soil contact (apply heavy press wheel pressure). Alternatively, on sandy soils seed can be dropped onto the soil surface and rolled in.

On non-wetting, sandy soils placing the seed in a deep furrow (8-10 cm) while maintaining good seed to soil contact can improve establishment. The benefits include: (i) the seedbed wets up evenly as most of the non-wetting soil is removed; (ii) the deep furrow channels light rain to the seedling; (iii) most of the weed seeds are removed from the seeding row; and (iv) the deep furrow maintains some shape well into autumn.

Some species have light, fluffy seeds (e.g. Rhodes grass) and a carrier (sand, fertiliser) can be used to improve flow through the seeder (mixing 1 kg of seed with 25 kg of carrier will improve the flow through the seeder). Alternatively use coated seed and adjust the seeding rate accordingly.

With air seeders, the air velocity required to move the fertiliser-seed mix can cause seed bounce, so it may be necessary to fit a ‘diffuser’ just above the seeding boots to allow the seed to drop into the furrow (or onto the soil surface) under gravity.
A wider row spacing (40-60 cm) may be beneficial especially in low to medium rainfall areas or in poorer soil types, as it allows the plants to explore a greater soil volume. Reduce the seeding rate in proportion to the row spacing, e.g. halve the seeding rate with a 50-55 cm row spacing. With wide row spacing the inter-row annual pasture takes on even more importance to maintain good production from the paddock.

f) Insect, pest and weed control after sowing
Post-sowing weed and insect control can be critical, especially along the south coast. Consider adding a ‘coal-mine canary’ such as lucerne, chicory or serradella to the seed mix that can act as an early warning indicator for insect damage. As these plants are unaffected by soil temperature they will germinate quickly and attract any insects that are present. Sow very low rates (50-100 g/ha) so they are not competitive and monitor regularly for damage. If they do not appear or quickly disappear there is a problem which needs to be addressed.

Monitor the paddock regularly, every 10-14 days after seeding to check for pests, weeds and the emergence of the grass seedlings.

Use a selective herbicide if broad-leaf weeds are an issue. There is currently limited information available on the use of pre-emergent herbicides and also on selective herbicides for post-emergent weed control, however mixtures of Dicamba and 2,4-D amine have been used successfully in the past.

When there is good spring and summer rain, grazing can be used strategically to control weeds, provided the grasses are well established and strongly anchored. However, in dry seasons grazing will need to be deferred and even low numbers of weeds will compete strongly for the limited soil moisture.

Uncontrolled grazing by kangaroos and rabbits during the first summer will adversely affect plant persistence, especially in dry seasons.

g) Grazing during the first summer
Seasonal conditions will determine when sub-tropical grasses can be grazed in the first year. Under favourable conditions it might be possible to graze 8-10 weeks after seeding, but when the seasonal conditions are very dry no grazing will be possible until late autumn or early winter.

Grazing should always be short and intense to ensure that new regrowth is not grazed. A light grazing will encourage tillering.

Sub-tropical grass seedlings have a very weak primary root system, so are very susceptible to grazing damage over the first summer. Plants with reasonable top-growth can still have a weak root system. It is important not to graze the grasses during the first summer until they have developed a strong root system. Grazing too early will result in stock up-rooting and killing many plants. Check whether plants are firmly anchored by testing how easily they can be pulled out by hand. Rhodes grass has long runners (stolons) that do not root down in dry soils and is therefore particularly susceptible to grazing damage in the first summer (test by pulling on the stolons).

What is successful establishment?
Successful establishment refers not only to a good seedling density in spring, but most importantly to persistence of the sown grasses through the first summer to give a good plant density in autumn.
With bunch grasses a plant density in the first autumn (e.g. mid-April) of 20-30/m² or more is excellent, 10-20/m² is very good, 6-10/m² is good while 1-5/m² is only fair and may not be adequate for good production. A stand with less than 1 plant/m² is a poor result and potential production will be severely constrained due to the low plant density. Under normal management there is negligible recruitment of bunch grasses and as with many perennial pastures there tends to be a slow decline in plant numbers over time. In the long-term, a pasture with 3-10 large bunch grasses/m² (depending on rainfall and the size of the crowns) will give good production.

Figure 5.4 shows the establishment and then the decline in plant numbers over a dry summer at three sites. At Mingenew and Badgingarra the grasses were well established before summer and there was still a good to very good plant density in autumn (except for setaria at Mingenew) despite the very dry summer conditions with little rain from early December until the end of March. However at the drier site at Buntine the grasses were small at the start of summer and most of the setaria and green panic plants died over summer. There was a second germination in autumn but survival of these plants over winter was problematic.

Grasses like Rhodes grass and kikuyu have the ability to spread and form new plants through their stolons and/or rhizomes. As a result, initially fairly poor stands with 1-5 plants/m² can be thickened by allowing the runners to root down and form new plants before they are grazed.

**Animal production**

Animal production from sub-tropical grasses is linked to the amount and quality of the pasture produced. The energy and protein requirements of the animal need to be met (Section 2.2).

The main advantage of summer-active perennials is that they produce out-of-season green feed, which is of comparatively good quality compared to the dry annual pasture residues at the same time of the year. They also provide a source of vitamin E.

In general, the feed quality of temperate perennial grasses is higher than sub-tropical perennial grasses when measured at an equivalent growth stage. But both species have a lower feed quality than annual legumes in spring. Table 5.4 summarises the dry matter digestibility and crude protein for a range of sub-tropical grasses from a trial at Wellstead.
Table 5.4 Dry matter digestibility (DMD) % and crude protein (CP) % in summer and autumn 2002/03

<table>
<thead>
<tr>
<th>Common name</th>
<th>Cultivar</th>
<th>12 February 2002</th>
<th>18 May 2002</th>
<th>14 January 2003</th>
<th>8 May 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>DMD (%)</td>
<td>CP (%)</td>
<td>DMD (%)</td>
<td>CP (%)</td>
</tr>
<tr>
<td>Setaria</td>
<td>Solander</td>
<td>79</td>
<td>13</td>
<td>72</td>
<td>12</td>
</tr>
<tr>
<td>Rhodes grass</td>
<td>Katambora</td>
<td>69</td>
<td>10</td>
<td>65</td>
<td>11</td>
</tr>
<tr>
<td>Finger grass</td>
<td>Strickland</td>
<td>78</td>
<td>11</td>
<td>72</td>
<td>11</td>
</tr>
<tr>
<td>Rhodes grass</td>
<td>Pioneer</td>
<td>68</td>
<td>10</td>
<td>63</td>
<td>10</td>
</tr>
<tr>
<td>Signal grass</td>
<td>Basilisk</td>
<td>71</td>
<td>15</td>
<td>62</td>
<td>12</td>
</tr>
<tr>
<td>Guinea grass</td>
<td>Gatton</td>
<td>75</td>
<td>15</td>
<td>64</td>
<td>11</td>
</tr>
<tr>
<td>Setaria</td>
<td>Splenda</td>
<td>75</td>
<td>14</td>
<td>70</td>
<td>13</td>
</tr>
<tr>
<td>Digit grass</td>
<td>Premier</td>
<td>71</td>
<td>13</td>
<td>65</td>
<td>12</td>
</tr>
<tr>
<td>Makarikari grass</td>
<td>Bambatsi</td>
<td>72</td>
<td>13</td>
<td>62</td>
<td>14</td>
</tr>
<tr>
<td>Digit grass</td>
<td>Jarra</td>
<td>–</td>
<td>–</td>
<td>73</td>
<td>11</td>
</tr>
</tbody>
</table>

The feed quality of sub-tropical grasses varies widely with management to a much greater extent than annual pastures or perennial legumes. Some factors that affect the amount, quality and feed intake of the sub-tropical grasses are summarised in Table 5.5. With most sub-tropical grass species there is a marked response in both pasture production and animal production to fertiliser nitrogen (N), providing soil moisture is available and temperatures are non-limiting.

**Balanced pasture**

To maintain the productivity and quality of sub-tropical grasses a good supply of nitrogen is essential. The cheapest form of nitrogen is from an annual legume-based pasture. The ideal sub-tropical grass pasture should be indistinguishable from an annual legume dominant pasture in winter and early spring. If well managed, then similar production can be achieved over winter and early spring to an annual pasture.

In general, the annual legumes that have the most potential as companion species are those that are best suited to the particular soil and climate. However, it may be preferable to use an early flowering variety to reduce competition with the sub-tropical grasses in mid-to late spring.
Suggested annual legumes for some of the key land management units include:

- deep sands – blue lupins, hard-seeded French serradella, yellow serradella
- winter-waterlogged sites – subterranean clover, balansa clover, burr medic, Persian clover
- summer-moist sites will support perennial legumes including strawberry clover as well as balansa, Persian and arrowleaf clovers.

The role of lotononis as a companion perennial legume is still to be investigated. Lucerne can be grown with sub-tropical grasses but they will be competing for soil moisture from mid-spring to late autumn and will grow more slowly in winter and early spring than annual legumes.

Establishing annual legumes

The ideal situation is to establish the annual legume in year one and manage the pasture to produce a large seed-bank. In year two, the annual pasture can be grazed hard and then sprayed out in early August with the sub-tropical grasses sown in early spring. The annual legumes will then regenerate from the seed-bank in year three.

However, in practice sub-tropical grasses are often sown into paddocks with a low annual legume content. With this scenario there are two options to increase the annual legume content.

(a) Over-sow annual legumes. This is necessary when the seed bank of annual legumes is very low.

In year 3 or subsequent years (only in year 2 if there are favourable growing conditions over the first summer-autumn) graze the paddock hard three to four weeks after the break and then apply SpraySeed® (1.5 L/ha). This will kill the volunteer annual pasture and burn-off the perennial grasses which will regrow in spring. Annual legumes can then be over-sown using a disc seeder or broadcast and trampled in by stock. Manage the pasture in spring to maximise seed-set of the annual legume.

(b) Manipulate the pasture to encourage the existing annual legumes. This option may be suitable when there is an existing seed-bank of hard-seeded annual legumes, but it is insufficient to give an annual legume dominant pasture.
Table 5.5 Some key factors affecting the amount, quality and feed intake of sub-tropical grasses

<table>
<thead>
<tr>
<th>Growth stage of plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>There is a strong effect of stage of growth (maturity) on feed quality. The best quality feed is new regrowth and quality declines rapidly from the commencement of flowering as there is an increase in the proportion of structural carbohydrates and lignin, which reduce digestibility. Typically across a range of species, the dry matter digestibility of regrowth declines by 0.1-0.4% per day. Rank growth has low palatability, poor feed quality and will be avoided by stock. Providing a protein lick can increase the intake of rank (mature) grasses.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fertiliser nitrogen – Effect on dry matter production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Many trials in the eastern States and overseas have shown large increases in dry matter production with nitrogen (N) fertiliser. Typically for a range of species, there is a linear response in herbage production to fertiliser N up to high annual application rates of 300-600 kg N/ha, depending on rainfall. The herbage response is often in the range 10-20 kg DM for each kg N/ha, but it can be highly variable. For example, in Queensland a range of sub-tropical grasses produced 3-11 kg DM for each kg N/ha during a period of low productivity and 17-48 kg DM for each kg N/ha during a period of high productivity (high temperatures, good rainfall).</td>
</tr>
<tr>
<td>There have been limited studies in WA, but kikuyu growing on a deep sand near Esperance gave a response of -11.5 kg DM for each kg N/ha up to 184 kg N/ha under favourable seasonal conditions (50 mm rain immediately after fertiliser application in January).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fertiliser nitrogen – Effect on protein and digestibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>There is usually a positive response of protein content to fertiliser nitrogen, but as sub-tropical grasses are very efficient at utilising N, the main response is increased herbage production. Nitrogen fertiliser often has a small positive (although sometimes negligible) effect on dry matter digestibility depending on soil fertility and the time of the year.</td>
</tr>
<tr>
<td>However, in the N fertiliser trial on kikuyu at Esperance (see above) there was a marked increase in the dry matter digestibility from 50-55% with no fertiliser to 60-70% with fertiliser N which would be sufficient for growing animals (Figure 5.5).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High temperatures</th>
</tr>
</thead>
<tbody>
<tr>
<td>With most sub-tropical grasses the optimum temperature for growth given non-limiting nutrients and soil water is high, often 25-35°C. Kikuyu and setaria have lower optimum temperatures for growth because they come from high altitude environments. On the other hand, high temperatures result in rapid growth, which may hasten maturity and result in a decrease in feed quality. Conversely, with mild temperatures the growth rate is lower, but the feed quality may be higher.</td>
</tr>
</tbody>
</table>

In year 3 (or later) graze the paddock hard three to four weeks after the break and then apply Spray.Seed® (~1.5 L/ha). This will kill the volunteer annual pasture, burn-off the perennial grasses and allow the annual legumes to become more dominant. The timing of the pasture manipulation will depend on seasonal conditions. Subsequently manage the pasture in spring to maximise seed-set of the annual legume.

**On-going management**

Reduce competition at the break of the season by grazing the perennial grass hard in late autumn and early winter. In spring the annual legume needs to be allowed to set-seed. The specific management will depend on the grazing pressure and whether the annual legume is an aerial seeder.
5.1 Bambatsi panic \textit{(Panicum coloratum)}

**Features**
- palatable, drought-tolerant tufted grass
- good tolerance of flooding
- adapted to fertile, clay soils
- will persist on sandy soils, but with low productivity
- slow to establish
- poor cool season growth.

Bambatsi panic (also makarikari grass) is an out-crossing species that is identified readily by its greyish-blue leaves with a distinctive white mid-rib. It is native to summer rainfall areas of southern and eastern Africa where it occurs on fine-textured soils, clay loams to cracking clays. This strong soil preference is borne out in Queensland and northern NSW where bambatsi panic is grown almost exclusively on self-mulching and cracking clay soils. The requirement is related to soil texture and not simply high soil fertility. It is cultivated in the United States where it is known as ‘klein grass’.

The potential of this species in WA is still being investigated. It will persist on coarse-textured soils, but productivity is usually very low. It may have a role on medium- to fine-textured soils in the eastern and north-eastern wheatbelt.

**Seasonal growth pattern**
Bambatsi panic has poor cool season growth, but in Queensland retains green leaf longer than most other sub-tropical grasses. In WA it appears to have slow autumn growth and is dormant in winter. It grows actively from mid-spring through to early December depending on moisture availability and then opportunistically over summer.

In summer rainfall environments, peak growth is in January to February and summer growth is much higher than either spring or autumn growth. Bambatsi panic has an indeterminate flowering pattern and can flower throughout summer.

**Establishment**
Bambatsi has small (960,000/kg), free flowing seed that can be sown with conventional seeding equipment. The suggested rate is 2-4 kg/ha when sown alone or 1-2 kg/ha in mixtures. Bambatsi seed is usually of good quality, with >50% germination. It should be sown no more than 10 mm deep and requires soil temperatures of about 17°C to germinate.

**Description**
- tufted perennial grass (1.5-1.8 m high) with very short rhizomes
- greyish-blue leaves with a distinctive white mid-rib
- inflorescence is an open panicle.
Germinating seed will enter a period of dormancy (‘hydropedesis’) if moisture is limiting, enabling the seed to germinate later under more favourable conditions. Seedlings have slow growth and compete poorly with weeds. In a comparison of seedling vigour, bambatsi seedlings were less than 20% of the weight of Rhodes grass seedlings nine weeks after sowing in the field.

Under favourable conditions bambatsi will continue to produce new tillers into late summer, but in WA it is usually restricted by moisture availability.

Livestock disorders
Secondary photosensitisation of young sheep and goats grazing wilted bambatsi panic during dry periods or from grazing fresh regrowth has been reported. Young cattle and horses can also be affected, but rarely mature animals (Section 2.3).

Management
With its slow establishment, grazing in the first year should be delayed until the plants have set seed. Check the plants are well anchored before grazing.

When established, bambatsi panic has good grazing tolerance and in Queensland there have been no problems with persistence under set-stocking. It is a palatable species, which is preferentially grazed by stock – particularly the young regrowth. It maintains good feed quality provided it is grazed to prevent it becoming tall and rank.

Companion species
The poor cool season growth should assist with the establishment of annual legumes in autumn. Bambatsi has been successfully grown with barrel medic in Queensland.

In WA, bambatsi is often sown as part of a mixture with other bunch grasses and Rhodes grass. Sowing it in a mixture is likely to favour the species with greater seedling vigour like Rhodes grass and green panic.

Cultivars
Three cultivars of makarikari grass have been released in Australia: ‘Pollock’ (a slightly stoloniferous type with short rhizomes), ‘Bambatsi’ (an erect bunch grass) and ‘Burnett’ (intermediate between other types). In the field there were no agronomic or production advantages of one cultivar compared with another, except Bambatsi had better seed production.

All commercial seed in Australia is now Bambatsi (public variety) due to its superior seed production. Cross-pollination between varieties has resulted in commercial bambatsi panic now having some traits from the other cultivars.
5.2 Consol lovegrass (*Eragrostis curvula* type *conferta*)

**Features**
- persistent, drought-tolerant, tufted perennial
- suited to well drained, sandy and loamy soils
- highly tolerant of soil acidity
- low feed quality and weed reputation result in low adoption.

African lovegrass or weeping lovegrass is a highly variable species native to southern Africa. It is now widely sown for rangeland regeneration and soil conservation in southern parts of the United States, South Africa and Argentina.

This is a controversial species as it includes both the pasture cultivar ‘consol’ and strains with low palatability that are serious weeds in many parts of Australia. Consol can be readily distinguished from the naturalised lovegrass in WA, as they belong to different ‘types’ within the *E. curvula* complex. The ‘wild’ type has prominent ridges on the leaf sheaths and long, thin, in-rolled leaves with greyish-green foliage.

Wild African lovegrass (*E. curvula* type *robusta blue*) is naturalised on road sides throughout south-western Australia, but has low palatability and is an aggressive coloniser of disturbed areas.162

Consol lovegrass (*E. curvula* type *conferta*) was selected by the NSW Soil Conservation Service for superior palatability, is less competitive than the naturalised type and is well grazed by sheep.169, 324

Consol is recommended for controlling spiny burr grass in central NSW, where it is grown with serradella on acid, sandy soils.115, 170

Consol lovegrass has not been widely tested in WA. The widespread distribution of the naturalised type indicates that it could be grown over much of south-western Australia.

**Seasonal growth pattern**
Consol lovegrass starts actively growing from early spring, while summer growth depends on moisture availability. It then grows actively from the first rains in autumn to early winter. It continues to grow slowly in winter, unlike many sub-tropical grasses which are

**Description**
- densely tufted perennial, with erect or weeping stems, 0.5-1.2 m high
- light blue-green to grey-green foliage
- leaves are flat, 15-25 cm long and up to 7 mm wide
- ligule is about 1 mm long with fringe of hairs and long lateral hairs
- leaf sheaths are purple at base, ridged with more hairs on the lower surface
- inflorescence is an open, olive green panicle up to 15 cm long which droops as it matures
- the plant develops into a solid tussock and as it ages the inner stems die, leaving an unproductive centre of the plant.
Consol lovegrass has very small seeds (5 million/kg) and needs to be sown at a very shallow depth (1-5 mm). A carrier (e.g. fine sawdust, fertiliser) may assist with uniform seed distribution. Rates of 1 kg/ha will give seeding densities of 100 plants/m² under favourable conditions, which subsequently decline to a stable sward with about 20 plants/m² in a medium rainfall environment.\(^{173}\)

Consol lovegrass can be sown earlier in spring than other sub-tropical grasses or even dry sown, as it induces seed dormancy until the conditions (soil moisture, temperature) are favourable for germination.\(^{173, 115}\) It has the ability to germinate at slightly lower soil temperatures than most sub-tropical grasses, with some germination at 10°C, increasing at 15°C with highest germination at 20°C.

If initial establishment is poor, the plant density can be increased by periodically allowing the stand to set seed.

**Livestock disorders**

None reported.

**Management**

New stands should not be grazed until the plants are well anchored. Good grazing management is essential, as coarse rank growth loses quality and is unattractive to livestock. Consol lovegrasses can tolerate short periods of set-stocking, but rotational grazing is preferable. It should be grazed regularly so that stock are always grazing young to medium regrowth. The grazing intensity should be sufficient to graze the area in less than three weeks, after which the paddock should be spelled for two to six weeks depending on rainfall. In Queensland, lovegrass rotationally grazed every eight weeks resulted in much higher dry matter production compared with a four-week grazing cycle.\(^{375}\)

Application of nitrogen to consol lovegrass stands will increase production and forage quality substantially. If P and K are applied to meet the needs of a companion legume, the requirements of the consol lovegrass will also be met. Consol lovegrass tolerates fire which can be used strategically to rejuvenate old stands. Rank pastures that have been under-grazed can be burnt in early spring to promote a new flush of growth. Pests and diseases are usually not a major problem.

**Companion species**

Serradella and subterranean clover are suitable annual legumes depending on the soil type. In NSW, consol lovegrass has been grown with lucerne on mildly acid soils and also with Rhodes grass and ‘premier’ digit grass.

**Cultivars**

‘Consol’ (public variety) is the only cultivar available in Australia. Seed may be difficult to obtain.
5.3 Digit grass (*Digitaria eriantha*)

**Features**
- persistent, drought-tolerant, tufted grass
- adapted to a wide range of soils
- good drought and cold tolerance
- tolerates heavy grazing once established
- low tolerance of waterlogging.

Digit grass (formerly *Digitaria smutii*) is an out-crossing species native to South Africa (Transvaal, Orange Free State, northern Cape) where it occurs in a range of habitats in summer rainfall areas (400-1000 mm). It is cultivated in South Africa, Argentina and Australia. This species also includes ‘Pangola grass’ (*Digitaria eriantha* ssp. *pentzii*, formerly *D. decumbens*) which must be vegetatively planted and is widely grown in tropical regions (not discussed here).

Digit grass has not been widely sown in WA, so its potential is largely unknown. However, in NSW digit grass has persisted and performed well on a wide range of soils and environments. It has survived severe droughts and persisted in the long-term under commercial grazing.55

**Seasonal growth pattern**
Digit grass grows actively from early spring and after the first rains until late autumn. It will grow opportunistically over summer if moisture is available. In WA, digit grass has negligible growth in winter, but in Queensland it is reported to produce new leaf growth in winter. Cool season growth (April to September) of Premier digit grass was similar to kikuyu in south-east Queensland.377

**Description**
- medium to tall (60-130 cm), tufted grass
- lowest leaf sheaths are densely hairy, but the leaves have few or no hairs
- stems are usually unbranched and up to 130 cm high
- finger-like seed head with one to three whorls arranged on a central axis.
Perennial pastures for Western Australia

Sub-tropical grasses

Digit grass tolerates fire, has good insect resistance and is generally disease-free, but the seed heads can be infected by a false smut (*Ephelis* sp.) under humid conditions.

**Companion species**
Digit grass is suitable for growing with a range of annual legumes. In NSW it is grown with Rhodes grass, Consol lovegrass and lucerne on coarse-textured, acid soils.

**Cultivars**
Two varieties, ‘Premier’ and ‘Apollo’, have been released in Australia.

‘Premier’ (public variety) was the first cultivar released in Australia. It has shown good persistence and production on a range of soils in Queensland.

‘Apollo’ (public variety) was selected for superior spring growth, but had inferior seed production to ‘Premier’ and has not persisted in commerce.

**Establishment**
Digit grass has a small, slightly hairy seed (3.3 million/kg), which may require a carrier to improve flow and ensure even distribution when sowing. Suggested sowing rate is 1-2 kg/ha of good quality seed when sown alone. Check the seed purity as many lines are contaminated with up to 30% Rhodes grass. Digit grass should be sown at 5-10 mm with good seed to soil contact. Seedlings can be slow to establish and are sensitive to moisture stress over the first summer.

**Livestock disorders**
No livestock disorders reported. It has a low soluble oxalate content.

**Management**
Digit grass can withstand heavy grazing for short periods (7-40 days), which should be followed by a rest period to allow the root reserves to be replenished and the opportunity to occasionally re-seed. Standing feed is still palatable after frosting and green shoots may be found near the ground.

Soil–climate adaptation

**Rainfall (est.):** >450 mm (south coast >400 mm)

**Drought tolerance:** Moderate to high

**Frost tolerance:** Low to moderate

Used in South Africa as ‘foggage’ (i.e. standing frosted hay)

**Soil type:** Grows on a range from acid sands to clay soils

**Soil fertility requirements:** Responsive to nitrogen. Persists on infertile soils, but production will be low

**Soil pH:** >4.2 (est.)

**Aluminium tolerance:** Moderate to high

**Waterlogging tolerance:** Low

**Salt tolerance:** Nil

**Ability to spread naturally:** Low

**Nutritive value**

**DMD:** 64% (regular cutting), 51% (feed deferred to winter)

**Crude protein:** 12.1% (regular cutting), 5.0% (feed deferred to winter)

**Establishment**
Digit grass has a small, slightly hairy seed (3.3 million/kg), which may require a carrier to improve flow and ensure even distribution when sowing. Suggested sowing rate is 1-2 kg/ha of good quality seed when sown alone. Check the seed purity as many lines are contaminated with up to 30% Rhodes grass. Digit grass should be sown at 5-10 mm with good seed to soil contact. Seedlings can be slow to establish and are sensitive to moisture stress over the first summer.

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**Management**
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Digit grass tolerates fire, has good insect resistance and is generally disease-free, but the seed heads can be infected by a false smut (*Ephelis* sp.) under humid conditions.

**Companion species**
Digit grass is suitable for growing with a range of annual legumes. In NSW it is grown with Rhodes grass, Consol lovegrass and lucerne on coarse-textured, acid soils.

**Cultivars**
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‘Premier’ (public variety) was the first cultivar released in Australia. It has shown good persistence and production on a range of soils in Queensland.

‘Apollo’ (public variety) was selected for superior spring growth, but had inferior seed production to ‘Premier’ and has not persisted in commerce.
5.4 Kikuyu (*Pennisetum clandestinum*)

**Features**
- creeping grass which forms a dense turf
- highly productive pasture, especially when grown with annual legumes
- tolerant of heavy grazing
- needs to be well managed to maintain feed quality
- excellent for stabilising soil and erosion control.

Kikuyu is a creeping sub-tropical grass that forms a dense turf and is tolerant of heavy grazing. It is widely used as a highly productive pasture for dairying and as a turf or lawn grass.

Kikuyu is native to the highlands of east and central Africa (i.e. Kenya, Ethiopia) where it grows on deep, red loams of volcanic origin. This region has high rainfall (1,000-1,600 mm), mild temperatures and occasional frosts. The common name ‘kikuyu’ comes from the tribe in Kenya where it was first collected.

Kikuyu was introduced into WA in the early 1920s. Compared with many other sub-tropical grasses the area suitable for growing kikuyu is well defined. It is largely confined to the high rainfall southwest, west coast and the south coast, although it may have a role in the West Midlands. There are currently about 60,000-90,000 ha of kikuyu based pastures in WA, mainly on the south coast. Kikuyu is competitive and has naturalised in moist disturbed areas from Dandaragan to Albany and along roadsides in high rainfall districts. Can be invasive in riparian zones so avoid planting near these areas.

A kikuyu-subterranean clover pasture enabled stocking rates to be increased by 65-95% and wool production by 70-103% compared with a subterranean clover pasture on the south coast of WA. It is suitable for fine wool production.

**Description**
- prostrate, creeping grass that spreads via rhizomes (underground stems) and stolons (runners) that readily root from the nodes
- left ungrazed it forms a loose, rank sward, but under grazing forms a dense turf
- leaf sheaths overlap and the leaf blades (5-20 cm) have a prominent mid-rib
- flowering is inconspicuous. The seed heads are mainly concealed within the leaf sheath and only white filaments are exposed for short periods.
Sub-tropical grasses

Seasonal growth pattern
The optimum temperature for growth is lower than for most sub-tropical grasses due to its origin (i.e. high altitude near the equator), where the mean maximum and minimum temperatures range from 16-22°C and 2-8°C respectively. In areas with a low incidence of frost, kikuyu starts growing rapidly in early spring and it can respond rapidly to summer or autumn rains. Very low growth rates are measured in winter. In more frost-prone areas it grows actively after the last frost in spring and in autumn until the first frost in late autumn or early winter.

Establishment
Kikuyu is normally sown alone and the suggested seeding rate is 1-2 kg/ha, resulting in 30-40 plants/m². It is often sown at 1 kg/ha or less because of the high seed cost. Seed should be sown at a depth of 10-20 mm. Seedlings are slow to establish and susceptible to moisture stress and waterlogging. Under controlled conditions, the optimum temperature for germination was 19-29°C, but at 14°C about 50% of the seed still germinated. Kikuyu will readily spread through animal dung. As a result, animals can be used to spread seed to new paddocks as a low cost method of establishment. Conversely animal movement from kikuyu paddocks into paddocks that are regularly cropped should be controlled.

Livestock disorders
A number of livestock disorders associated with kikuyu are reported in the literature, however they are not common.

Soil–climate adaptation
- Rainfall (est.): >500 mm (south coast >400 mm)
- Drought tolerance: Moderate to high
- Frost tolerance: Moderate. The first frost in autumn results in leaves turning yellow and the plant becomes dormant. Stolons/rhizomes are unaffected and will regrow when temperatures exceed minimum for growth
- Soil type: A wide range, including deep sands. It will grow on fine-textured soils, but spreads more rapidly on coarse-textured soils. Not suited to shallow soils and waterlogged-saline soils
- Soil fertility requirements: High, very responsive to N fertiliser (Figure 5.5)
- Soil pH: >4.0
- Aluminium tolerance: Good
- Waterlogging tolerance: Moderate
- Salt tolerance: Slight to moderately low (if not waterlogged)
- Ability to spread naturally: Very good from stolons, rhizomes and seed spread in animal dung

Nutritive value
- DMD: 59-63% (monthly cuts)
- Crude protein: 10.4-14.3% (low to high fertiliser N with monthly cuts)

Environmental benefits
- Groundwater recharge control: Good, roots were measured to 3 m on a sand over laterite soil
- Soil erosion control: Very good
- Weed control: Competitive and suppresses summer weeds
Sub-tropical grasses

Management
New stands should not be grazed until the runners are >20 cm and the plants are strongly anchored. When grazing, monitor the paddock regularly to ensure stock are not pulling out runners. Kikuyu produces stem material throughout the year, so feed quality is strongly influenced by the stage of regrowth (i.e. the proportion of leaf to stem). Kikuyu pastures are most productive when kept short, 2-5 cm (depending on density), which corresponds to about 1400 kg green DM/ha. This promotes new leaf growth, which is more nutritious than older growth.

A high stocking rate is required after the break in autumn to maintain kikuyu at 1400 kg DM/ha. This stocking rate enables the annual clovers and grasses to germinate. Kikuyu provides a good refuge for redlegged earth mite, which can drastically reduce the number of clover seedlings. Control RLEM with strategic sprays in spring (e.g. Timerite®).

In winter the pasture should contain about 30-40% kikuyu with the rest being annual grasses and legumes, which will increase the winter production. In spring, when the kikuyu starts growing actively, graze the pasture to 1400 kg DM/ha and do not let the kikuyu exceed 3,000 kg DM/ha (this amount resembles a well-mown lawn with one to two weeks regrowth). Graze hard in late spring to avoid rank growth.

Over summer use a high stocking rate to graze the pasture to ~800 kg DM/ha (about 1 cm or less) to maintain the pasture quality. If there is prolonged drought, defer summer grazing particularly if stock are pulling up kikuyu runners.

Kikuyu showing frost damage

Kikuyu contains low to moderate levels of oxalic acid (0.039-2.4%), but no problems have been reported. Occasional deaths due to kikuyu poisoning have been reported with cattle, sheep, goats and horses from New Zealand, South Africa and Australia. The cause of death is unknown, but it may be associated with the army worm caterpillar. The incidence in WA is low, but deaths have been recorded, so it is useful to outline the symptoms.

Poisoning is normally associated with hungry stock grazing lush, rapidly growing kikuyu following rain (or nitrogen fertilisation). Typically, stock show symptoms one to two days after consuming toxic pasture. These symptoms include depression, inappetence, sham drinking, rumen distension, dehydration, staggering and collapse. If symptoms occur, remove stock immediately and either feed hay or move to a paddock with no kikuyu grass. Unfortunately, poisoned stock are likely to die.

Kikuyu can accumulate nitrogen compounds in excess of animal requirements when heavily fertilised with N, and this can reduce animal performance. The solution is to avoid large single applications of N (>50 kg/ha/month). Apply as split applications to avoid excessive nitrogen levels in the pasture.
Kikuyu is very tolerant of heavy grazing and can tolerate set-stocking. However, in some cases, set-stocking has reduced the carrying capacity compared with rotational grazing. If growth is rank, then slashing old growth to 5 cm will promote new leaf growth and will also promote the growth of annual legumes and grasses.

In a kikuyu dominant pasture, energy may be limiting resulting in a protein to energy imbalance, due to the low content of readily digestible (i.e. non-structural) carbohydrates. Also, kikuyu is low in sodium, which could be a problem in kikuyu-dominant pastures.

‘Kikuyu yellows’ is a fungal disease where affected yellow patches spread out leaving bare areas which are invaded by weeds. It occurs mainly in the sub-tropics and is unlikely in south-western WA.

Companion species
Kikuyu combines well with subterranean clover, although in years with a dry autumn the annual legume can struggle to establish. On deep duplex soils and deep sands kikuyu combines well with yellow serradella.

On summer moist sites it combines well with perennial legumes like strawberry clover or possibly greater lotus. It is not normally sown with other perennial grasses, although can be sown with Rhodes grass.

There is some evidence that decaying stolons release compounds that can be allelopathic, i.e. reduce germination of other species.

Cultivars
‘Common’ kikuyu is a non-seeding type that is propagated by runners. It is narrow-leaved and forms a dense sward.

‘Whittet’ (public variety) is the main variety sown in WA. Compared with the ‘common’ type, it is a comparatively taller variety characterised by broad leaves, thicker stems and longer internodes on the stolons. It persists well under lower fertility conditions and is free-seeding, but is susceptible to ‘kikuyu yellows’.

Three other varieties have been released, but seed may be difficult to obtain.

‘Breakwell’ (public variety) is similar to the common type, but is a seeding type as 80% of the plants are bisexual. It is more densely tillered than Whittet and spreads more quickly, but is less productive. Recommended for soil conservation and turf, but not pastures.

‘Noonan’ (public variety) was developed from Whittet and Breakwell for tolerance to the disease kikuyu yellows. Will set seed without the regular cutting that is required to stimulate seed production in other cultivars.

‘Crofts’ (public variety) is a taller variety with more upright, narrower leaves and has better cold tolerance than Whittet, but is susceptible to kikuyu yellows.
5.5 Panic grasses (*Megathyrsus maximus*)

**Features**
- tufted, highly palatable, leafy grass
- moderate drought tolerance
- good spring growth
- requires fertile conditions for good performance
- does not tolerate waterlogging or flooding.

The panic grasses (formerly *Panicum maximum*) are one of the major sown sub-tropical grasses and are widely used in South America, Japan, and India as well as eastern Australia. They are shade tolerant and are often found around tree lines in their native environment (tropical and sub-tropical Africa) taking advantage of the improved nutrition from the leaf litter. *M. maximus* is a diverse species as it includes both the tall (up to 4 m), tropical Guinea grasses and the shorter sub-tropical panic grasses (formerly called *P. maximum* var. *trichoglume*) which are the type of interest for WA. The latter are better known by the variety names: ‘Gatton’ panic and ‘Petrie’ (or green) panic.

Panic grasses appear to have good potential in WA, both along the south coast and in the northern agricultural region.

**Seasonal growth pattern**
The panic grasses have a similar growth pattern to the other warm season grasses. If the prevailing weather conditions are mild there can be moderate growth in early winter, otherwise they are dormant in winter. The panics are one of the first sub-tropical grasses to start growing in spring when the temperatures increase. They will continue growing until soil moisture is depleted, then opportunistically over summer and after the rains in autumn. They respond rapidly to light showers of rain and also after the rains in autumn when the temperatures are mild to warm.

Like most sub-tropical grasses, panic grasses prefer high temperatures with maximum growth at 30-36°C/25-31°C (day/night temperature) under controlled conditions. The growth rate falls sharply when the temperature is below 18°C/13°C, with negligible growth below 15°C/10°C.

**Establishment**
The panics have very small seeds (1.2 million/kg) that must be sown into a fine seedbed with shallow sowing (<10 mm) and good seed-soil contact. Sow 2-4 kg/ha of good quality seed when sown alone or 1-2 kg/ha when sown in a mixture. The seed requires contact with moist soil for three days to germinate. Seedlings have good vigour.

**Description**
- moderately tall, leafy, tufted grass (0.8-1.8 m)
- leaf sheath is often hairy
- flower heads are an open, branched panicle.
Livestock disorders
Panic grasses contain low to moderate levels of oxalate (0.52% summer, 0.80% autumn) which can result in big head in horses and occasionally nephrosis or hypocalcaemia in ruminants (Section 2.3).

Pastures dominated by panics can cause secondary photosensitisation in stock. Reports from Queensland suggest it is more likely to occur when the grass is young or growing rapidly after a dry spell, with young stock (especially sheep) and when the stock are in a stressed condition (Section 2.3).

Management
In the first year, the pasture should not be grazed until the plants have developed crowns, have set some seed and/or are well anchored.

The panics are very palatable and often preferentially grazed in mixed swards. However, they are not tolerant of heavy grazing and require rotational grazing. Allow the plants to set seed every two years.

Companion species
Should be compatible with a range of annual legumes. Panic grasses are sometimes sown in a mix with Rhodes grass and digit grass in eastern Australia.

Cultivars
There are two commercial varieties in Australia:
‘Petrie’ or green panic (public variety) is an erect, tall (seed heads up to 1.8 m), tufted grass which is distinguished from Gatton panic by its light green foliage, the lower surface of its leaves and its leaf sheaths have sparse, long hairs (compared with short down-like hairs) and the leaf mid-rib is less pronounced. Has low frost tolerance.

‘Gatton’ panic (public variety) originates from Zimbabwe and is a robust, tufted grass that is agronomically similar to green panic, slightly less drought-tolerant and more sensitive to frosts, but superior on low fertility soils. Gatton panic has longer and broader leaves than green panic, with a more prominent mid-rib, finely pubescent leaf sheaths, greener foliage and often contains anthocyanins (purple pigmentation) near the base of the stems.
5.6 Rhodes grass (*Chloris gayana*)

**Features**
- creeping perennial which spreads through stolons (runners)
- adapted to a range of soil and climatic conditions
- easy to establish with good seedling vigour
- moderate to high drought tolerance
- moderate feed quality
- may not persist under stressful conditions.

Rhodes grass is one of the main sub-tropical grasses used in agriculture and is widely grown in Africa, Australia, Japan, South America and under irrigation in the Middle East for both forage and soil conservation purposes. Rhodes grass is a morphologically variable out-crossing species, which is native to east, central and southern Africa where it occurs in open grasslands. It was introduced into Australia by soldiers returning from the Boer war, who brought with them the common variety (cv ‘Pioneer’).

In WA, Rhodes grass has been one of the most widely sown sub-tropical grasses in the last 10 years. It often dominates when sown in a mixture due to its good seedling vigour and ability to spread through runners. There is a query as to the longevity of stands under stressful conditions, as some Rhodes grass pastures only persist for one to three years, due to a combination of stresses including: low fertility, cold-wet soils, frost, over-grazing and competition from annual pastures.

**Description**
- stoloniferous and tufted, leafy perennial grass
- erect or ascending stems 0.5-2 m tall
- leaves are hairless and 15-50 cm long
- leaves on the stolons are shorter with 2-4 leaves per node
- brown, digitate seed head in the shape of an open hand.
Sub-tropical grasses

Perennial pastures for Western Australia

Like most sub-tropical grasses, Rhodes grass prefers high temperatures with maximum growth at 30°C/25°C (day/night temperature) under controlled conditions. Growth is reduced greatly below 18°C/13°C and there is negligible growth when the average daily temperature is below 8°C.

Establishment
Rhodes grass is readily established from seed. The seed germinates quickly (1-7 days) depending on temperature. Rhodes grass displays good seedling vigour and often achieves full groundcover within three months of sowing. Rhodes grass has a high shoot/root ratio and a weak primary root system, so plants rely on developing a strong secondary root system and are easily pulled out by stock during the establishment period.

The suggested seeding rate is 2-3 kg/ha of good quality seed when sown alone, or 1-2 kg/ha when sown as a mixture. The seed can be drilled at 5-10 mm followed by press wheels, or alternatively broadcast onto a firm, fine seedbed and then rolled to give good seed-soil contact. Rhodes grass seed is light and fluffy and as a result is difficult to handle. Use coated seed, or with uncoated seed use a carrier to improve the flow through the seeder.

The optimum temperature for germination is 15-40°C, but a small proportion of seeds will germinate at lower temperatures. Unlike some sub-tropical grasses, Rhodes grass seeds germinate at low soil water contents and once germination has started it is irreversible.

Under conditions of marginal soil moisture Rhodes grass may be the first species to germinate.
Rhodes grass can compensate for poor seedling establishment by rapid stoloniferous growth to form a dense stand if it is carefully managed in the first two years.

Livestock disorders
None have been reported. Contains low levels of oxalate, so is not hazardous for horses.

Management
Premature grazing can severely damage a new Rhodes grass pasture as stock can up-root plants. Rhodes grass should not be grazed in the first year until the plants and runners are well anchored which may not occur until the autumn rains, as the stolons will only root into moist soils. Test the plants to see how well they are anchored before grazing.

Established stands can withstand periods of set-stocking, but heavy grazing can damage the stand. In more intensive systems, rotational grazing should result in higher production and better persistence.

In general, palatability is good but declines rapidly with maturity, so Rhodes grass should be grazed to prevent flowering. The digestibility of Rhodes grass varies widely, but is generally similar to other sub-tropical grasses at an equivalent growth stage.

Rhodes grass can survive fire, although hot fires can kill the small plants growing on stolon nodes.

Companion species
Can be grown with annual legumes like subterranean clover, burr medic and serradella on sandy, well-drained soils, or subterranean clover, balansa clover and slender serradella on winter-waterlogged soils. Graze the sward hard in late autumn to give the annual legumes an opportunity to establish.

Can be sown as a monoculture, but is often sown in a mix with bunch grasses or occasionally with kikuyu.

Cultivars
There are two main groups of Rhodes grass cultivars – diploid and tetraploid types – the latter having double the number of chromosomes.

**Diploid types:** These come from sub-tropical regions, are more robust and flower over a wide period as the flowering response is insensitive to day length. In general, they have superior frost tolerance, salt tolerance and drought tolerance than the tetraploid types.

‘Pioneer’ or common (public variety) is quite variable but is characterised as an early flowering, erect plant with moderate leafiness. It is widely naturalised in sub-tropical eastern Australia, but has been superseded by newer varieties.

‘Topcut’ is a selection from Pioneer developed primarily for hay production, which is reported to be leafier, finer-stemmed and produce more dry matter.

‘Katambora’ (public variety) is mid-flowering and is characterised by strong stolon development, heavy seeding and drought tolerance. In Queensland, it is more persistent on low fertility soils than other cultivars.

‘Finecut’ is a selection from Katambora developed primarily for hay production and is reported to be leafier, finer-stemmed and to produce more dry matter in Queensland.

‘Nemkat’ is a selection from Katambora that has resistance to all the known root-knot nematodes in the north-Queensland tobacco growing areas. Untested in WA.

**Tetraploid (giant) types:** Late flowering types from tropical regions that are tall (>1.8 m) and have coarse leaves, stems and stolons. They are strongly stoloniferous, leafy, late flowering, drought-tolerant and have high dry matter production.

Their main advantage is that they only flower late in the season (as they flower in response to short-day lengths), so feed quality is maintained for longer. However, when grown under optimal conditions and grazed regularly there is little if any difference in the animal intake or the digestibility of different types of Rhodes grass.

‘Callide’ (public variety) an introduction from Tanzania is widely grown in Australia and is the only tetraploid variety on the market.

Future developments: Salt-tolerant varieties are being developed in eastern Australia, but these are principally being selected for use with brackish irrigation water rather than salt-affected land.
5.7 **Setaria** (*Setaria sphacelata* complex)

**Features**
- moderate to tall, bunch grass
- comparatively good cool season growth
- some varieties have good frost tolerance
- contains moderate to high levels of oxalate.

The genus *Setaria* includes a number of species that are used in agriculture. *Setaria sphacelata* var. *sericea* (setaria) is an out-crossing species that is widespread in its native Africa, but is mainly from regions where the rainfall is more than 750 mm and without a pronounced dry period. In Queensland and northern NSW setaria is mainly grown in coastal districts.

*Setaria splendida* is suited to humid lowland tropics, but has to be planted vegetatively as the seed is sterile. However, the variety ‘Splenda’ is a seeding hybrid, which has shown some promise in limited testing in WA.

Purple pigeon grass (*Setaria incrassata*) is a bunch grass native to Zimbabwe where it grows on black cracking clays. In northern NSW and Queensland it is grown on fine-textured soils with bambatsi panic and Rhodes grass. On these soils it is easy to establish and shows excellent seedling vigour. To date attempts to grow this species in south-western Australia have been unsuccessful. It appears to require high soil temperatures (~25°C) to germinate, which would preclude its use in WA.

The following refers to *Setaria sphacelata* var. *sericea* and the seeding hybrid Splenda.

**Seasonal growth pattern**
In WA, setaria grows actively in autumn after the rains. In areas with mild temperatures, winter growth is better than the other sub-tropical grasses, but in cold areas the plants are dormant over winter. *Setaria* resumes active growth in early spring and will grow opportunistically in summer depending on soil moisture. In northern NSW, setaria has a similar growth pattern to kikuyu.

**Description**
- robust, erect, densely tufted grass (0.9-1.8 m)
- base of vegetative tillers is flattened (fan-shaped)
- leaves are generally broad and mostly hairless
- ‘cigar’-shaped seed head.
Establishment
The suggested seeding rate is 1.5-2.5 kg/ha of good quality seed when sown alone. Sow less than 15 mm deep into a firm seedbed. Seedling growth is slow in the first year, but once established the plants grow vigorously. It will persist on low fertility soils

Livestock disorders
Setaria contains moderate to high levels of oxalate, so is unsuitable for horses and can occasionally cause nephrosis or hypocalcaemia in ruminants. Pastures containing a high content of setaria (>95%) have resulted in cattle poisoning in Queensland. The oxalate content depends on the variety, the growing conditions, stage of growth and increases with fertiliser nitrogen and potassium. The oxalate tends to be higher in the leaf blades than the stems while there is no oxalate present in the seed heads (Section 2.3).
Management
In the first year defer grazing until the plants are well anchored. Test the plants to ensure they are strongly anchored before grazing.

When established, heavy grazing is required to maintain vegetative growth and palatability. Young leafy regrowth has good digestibility, but this decreases rapidly as the plant matures, so regular rotational grazing is required.

Setaria is often used for hay and silage in South Africa.\textsuperscript{136, 404}

Companion species
Can be grown with other bunch grasses and Rhodes grass, but under good growing conditions is reported to suppress the growth of companion grasses.\textsuperscript{136} Should be compatible with a range of annual legumes.

Cultivars
There are four cultivars of \textit{S. sphacelata} var. \textit{sericea} and one seeding hybrid. The early cultivars grown in Australia, Nandi and Kazungula, were direct introductions from Kenya and Zambia respectively.

‘Nandi’ (public variety) is from a highland region of Kenya and was selected for leafiness and vigour. It has less drought tolerance than Kazungula and is susceptible to frost damage.\textsuperscript{203} Nandi contains the lowest levels of oxalate (3.0-3.7\%) among the commercial varieties.\textsuperscript{184}

‘Kazungula’ (public variety) is an ecotype from Zimbabwe that has good flood and drought tolerance and has slightly better frost tolerance than Nandi. It is a more robust and coarser grass than Nandi and flowers about one month later in spring.\textsuperscript{203} Kazungula contains high levels of oxalate (3.3-7.0\%).\textsuperscript{178, 184}

‘Narok’ (public variety) was bred for improved frost tolerance and will withstand frosts of -3°C with negligible leaf damage, although heavier frosts will kill the leaves.\textsuperscript{203} It has better cool season growth than Nandi and Kazungula and is also more leafy and palatable.\textsuperscript{203} It contains moderate levels of oxalate. Seed production is poor, as it has a low number of flowering tillers.

‘Solander’ (public variety) is similar to Narok in both appearance and agronomy, but has superior seed production. It was developed because of problems with low seed production in Narok.\textsuperscript{8, 203}

Cultivar ‘Splenda’\textsuperscript{\textdagger} is a seeding hybrid from a cross of \textit{S. sphacelata} var. \textit{sericea} and \textit{S. sphacelata} var. \textit{splendida}. It is a tall (>2 m at flowering), robust, leafy grass which is later flowering than Nandi and Narok and has some frost tolerance. It has a high content of oxalate with the concentration in young leaf (4.7\%) comparable to Kazungula.\textsuperscript{135} Splenda\textsuperscript{\textdagger} was developed for the humid tropics of north Queensland, but has shown some promise in preliminary testing in coastal districts of WA.
5.8 Signal grass (*Urochloa decumbens*)

**Features**
- slowly creeping grass which can form a dense sward
- grazing-tolerant once established
- tolerant of acid soils and high soil aluminium
- poor cool season growth and sensitive to frosts
- can cause secondary photosensitisation in stock.

Signal grass (formerly *Brachiaria decumbens*) originates from open grasslands on the Great Lakes plateau in Uganda and the surrounding countries. It is now widely sown in central Brazil where 40 million hectares of the savannas have been sown to *Urochloa-Brachiaria* species. Signal grass prefers the wet tropics, but has reasonable drought tolerance as it is adapted to areas with a dry season up to 4-5.5 months.

Signal grass has not been tested widely in WA. Limited observations and testing suggest it has some potential on moderately well to well-drained sandy soils in coastal districts and in the northern agricultural region in areas with mild winters and a low incidence of frosts. However, even in these environments there are questions about its long-term persistence.

**Seasonal growth pattern**
Signal grass is one of the first warm season grasses to stop growing as the temperature cools down in late autumn and has negligible growth over winter even in areas with mild temperatures. It is often one of the last sub-tropical grasses to start growing actively in spring and then grows opportunistically in summer if moisture is available.

**Establishment**
Signal grass has a comparatively large seed (220,000/kg), so it usually establishes readily. The suggested sowing rate is 2-4 kg/ha when sown alone, at a depth of 5-10 mm. Under good conditions it will establish quickly and achieve full groundcover within three months.

Signal grass seedlings are tolerant of pre-emergent application of atrazine.

**Description**
- low to medium height (30-45 cm), slowly creeping grass (stoloniferous) that can form a dense sward under ideal growing conditions
- weakly stoloniferous with trailing stems that can root at the nodes
- stems are hairy with leaves 8-10 mm wide and often of light-green colour
- seed head is arranged like a railway signal with 2-5 racemes (2-5 cm long)
- flowers in response to short day lengths.
Livestock disorders
There are reports from Queensland that sheep grazing pastures dominated by signal grass have been affected by secondary photosensitisation. Contains low (1.0-1.1%) concentrations of oxalate (Section 2.3).

Management
The feed quality of signal grass is similar to other warm season grasses, but it requires heavy grazing to maintain quality when actively growing, as feed quality declines rapidly with maturity. The palatability is good except when the flowering stems are mature.

High animal production (liveweight gains of 225-950 kg/ha) has been reported from various grazing studies with cattle in Queensland and South America.

Companion species
Where it is well suited, signal grass is aggressive and out-competes other species to form a pure sward. In north Queensland signal grass is used strategically to reduce pressure on mixed (grass-legume) pastures during the cool season as it can tolerate heavy grazing. In WA the conditions are less favourable for signal grass and a companion annual legume can be grown.

Cultivars
‘Basilisk’ (public variety) often simply called ‘signal grass’ is the only cultivar available in Australia.
5.9 Other warm season grasses

Buffel grass (*Cenchrus ciliarus*)

**Features**
- hardy, drought-tolerant bunch grass
- suited to warm to hot environments
- widely sown and naturalised in northern Australia
- not recommended due to weedy history
- moderate feed quality
- contains moderate to high concentrations of oxalate.

Buffel grass is a bunch grass native to the hotter and drier areas of India, the Mediterranean basin and tropical and southern Africa. It has been widely sown in similar dry, warm to hot environments, including northern Australia, Queensland and western NSW.

Buffel grass is widely naturalised in arid environments, including central Australia and the pastoral regions of WA. It is a widespread weed from Shark Bay to the Pilbara and adjacent desert. Buffel grass is invasive and displaces native species and can be difficult to remove where it is well suited.

**With this history as a problem weed, buffel grass is not recommended for south-western Australia.**

From limited evaluation in south-western Australia, it appears that buffel grass will only persist in the north-eastern wheatbelt. In other districts it is unlikely to persist because of its limited cold tolerance. Buffel grass prefers high temperatures with maximum growth at 30°C/25°C (day/night temperature) under controlled conditions. The growth rate falls sharply when the temperature is below 18°C/13°C, with slow growth below 15°C/10°C.

Buffel grass has a light and fluffy seed, which makes it difficult to sow with conventional machinery. A carrier such as fertiliser or cracked grain will improve distribution through an airseeder or combine. The suggested sowing rates vary from 2-3.0 kg/ha, but 1.0 kg/ha of good quality seed can be sufficient to establish a pasture. Under suitable conditions buffel grass establishes readily. In the first year, buffel grass should not be grazed before seed-set. Stands can be thickened by allowing seed-set and then resting the paddock after summer rain.

**Description**
- moderate to tall bunch grass (0.4-1.5 m)
- stems have a number of branches
- foxtail shaped seed head with many bristles
- individual spikelets fall when ripe.
Sub-tropical grasses

When it is actively growing buffel grass can be set-stocked or rotationally grazed. The young regrowth is very palatable for stock and even at maturity the palatability is fair. Buffel grass contains moderate to high levels of oxalate (3.5-4.3%), so can cause big head in horses and occasionally hypocalcaemia or nephrosis in ruminants (Section 2.3).

Soil–climate adaptation

Rainfall (est.): >300 mm (in areas with mild to warm winters)

Drought tolerance: Extreme

Frost tolerance: Low

Soil type: Adapted to a range of well drained soils, except deep sands

Soil fertility requirements: Good fertility with a high P content

Soil pH_u: >5.5 (est.)

Aluminium tolerance: Very sensitive

Waterlogging tolerance: Low

Salt tolerance: Slight

Ability to spread naturally: High by seed, where well adapted

Nutritive value

DMD: 67% (leaf), 53% (stem)\(^{385}\)

Crude protein: 6.2-11.0%\(^{359}\)

Cultivars

There have been 11 buffel grass cultivars released in Australia, but many are no longer commercial. They can be grouped according to height into tall, medium and short types:

**Tall buffel grasses** (1.3-1.5 m at maturity)

‘Biloela’ (public variety) is now the main tall variety. It is late maturing and is suited to fine-textured soils.

**Medium height buffel grasses** (1.1 m at maturity)

‘Bella’\(^{138, 139}\) was selected for improved spring growth, is late maturing and suitable for medium- to fine-textured soils.

‘Viva’\(^{138, 139}\) was selected for improved spring growth, is late maturing and suitable for medium-textured soils.

**Short buffel grasses** (0.4-0.9 m at maturity)

‘Gayndah’ (public variety) has mid-season maturity and is suitable for coarse- to medium-textured soils.

‘American’ (public variety) is a early maturing variety (USA buffel is similar) and is suitable for coarse- to medium-textured soils.

‘West Australian’ (public variety) is a short (0.4-0.7 m), early flowering variety which was first observed growing on the north-west coast of WA in the late 19th century and was probably introduced by camel traders. It was subsequently widely sown in the pastoral districts of northern Australia, but has been superseded by more productive varieties.\(^{293}\)
Couch grass (*Cynodon dactylon*)

**Features**
- creeping, sward-forming grass
- spreads by both stolons and rhizomes
- tolerates heavy grazing
- widely naturalised on sandy soils in the agricultural region
- low productivity unless good fertility
- difficult to remove once established.

Couch (or Bermuda grass) is native to southern Africa and south-east Asia. It has been widely used in tropical and warm temperate regions as a pasture grass and is one of the major turf grasses in the world. Couch grass is widely sown in the south-eastern United States, where they have developed hybrids with improved productivity and forage quality.

Pastures in south-eastern US consisting of Bermuda grass and Italian ryegrass have produced animal liveweight gains of 1132 kg/ha from 204 grazing days. With adequate N fertiliser, improved forms can produce twice the biomass of naturalised types.

In WA, couch grass has been sown widely as a lawn and occasionally in paddocks, but it has now naturalised on sandy soils (rainfall >350 mm) in the agricultural region. The deep rhizomes result in couch grass being difficult to remove with cultivation once it is established and it can cause problems with cropping. The naturalised couch grass will compete with sown warm season grasses during the establishment phase.

Couch grass is dormant in winter and grows actively from mid-spring to summer and then in autumn until the first frosts. For good growth it requires warm temperatures with daily mean of about 24°C.

Couch grass can be sown from seed or vegetatively propagated from runners. The suggested sowing rate is 2-5 kg/ha and the seed should be broadcast on the surface and rolled, or drilled no more than 5 mm deep. Couch grass is tolerant of grazing and must be grazed heavily as the feed quality and palatability decline with maturity.

**Description**
- low, creeping grass (<30 cm) that spreads by both rhizomes and stolons
- roots and tillers form at the nodes on the stolons
- forms a ‘dense sward’ under high fertility conditions
- fine leaves, 2-5 cm long, 2-4 mm wide
- seed heads are digitate (finger-like) with 2-7 spikes on erect stems which turn purple or reddish-brown after flowering.
Soil–climate adaptation

**Rainfall (est.):** >450 mm

**Drought tolerance:** Moderate to high

**Frost tolerance:** Moderate, leaf growth killed by –2°C, but grows back from rhizomes in spring

**Soil type:** Adapted to well drained soils, particularly coarse-textured including deep sands

**Soil fertility requirements:** Moderate to high for good production, will persist under low fertility, very responsive to N fertiliser

**Soil pH ca:** >4.0 (est.)

**Aluminium tolerance:** Good

**Waterlogging tolerance:** Moderate

**Salt tolerance:** Moderate (if not waterlogged)

**Ability to spread naturally:** Spreads by stolons, rhizomes and seed

**Nutritive value**

**DMD:** 64% (leaf), 59% (stem)

**Crude protein:** 8.3-14.0%

**Environmental benefits**

**Soil erosion control:** Useful pioneer plant

**Weed control:** Moderate ability to out-compete weeds under fertile conditions

Stock deaths grazing young plants have been recorded due to hydrocyanide, but they are very rare. Toxicity seems to be confined to the coarser leaf, loosely branched forms rather than the fine-leaf types.

The prostrate, creeping growth habit results in couch grass being a useful plant for soil conservation and as a pioneer species on denuded areas. The improved types of couch grass may have a role as a permanent pasture on sandy soils, particularly on soils where subsoil moisture is available over summer.

**Cultivars**

Numerous cultivars of couch grass have been developed, especially as turf grasses. Couch is rarely sown as a pasture grass, but seed is available. The main varieties are:

Giant NK37 (public variety) is a giant Bermuda grass developed in the US as a pasture grass. It requires some subsoil moisture over summer to be productive.

Bermuda grass (or common) is a smaller form which is used as a lawn grass.
Perennial pastures for Western Australia

Sub-tropical grasses

Elephant grass (*Pennisetum purpureum*)

Features
- very tall, robust grass
- vegetatively propagated
- rapid growth under moist, warm conditions
- useful windbreak species.

Elephant grass is a very tall grass that is native to Zimbabwe, but has now been introduced into most sub-tropical and tropical countries. High animal production has been recorded from elephant grass pastures in tropical environments, e.g. beef cattle on mature elephant grass had liveweight gains of 549 kg/ha. In Queensland, elephant grass is a highly productive pasture in the humid tropics (850-2,500 mm).

Elephant grass is planted vegetatively as cuttings, because the seed quality is poor. Cuttings are taken from the hard sections of the stem, and each cutting requires at least three nodes, with two nodes buried in the soil. The cuttings are sown in spring, usually in rows (alleys) with a within row spacing of about 1 m.

Elephant grass needs to be managed to keep it at a height of 1 m or less, as young shoots are soft, succulent and palatable, while the tall growth is coarse and has a low palatability. Feed quality depends on the ratio of leaf to stem and declines with age.

In WA elephant grass is used as a windbreak for market gardens on the Swan coastal plain, with very limited plantings as forage on farms. The potential of elephant grass as a forage (non-irrigated) in WA is unknown, but it will be limited by the requirement for vegetative propagation. It has naturalised along creeklines in the Darling Scarp near Perth and should not be sown near waterways.

Cultivars
The common form is a robust, coarse plant which can grow very tall (up to 4 m).

The only variety in Australia, ‘Capricorn’ (public variety) was selected as a late flowering, ‘grazing type’ with medium height (1.8-2.4 m) and thick succulent stems, strong crowns and vigorous stooling.

A dwarf type (‘Mott’) has been developed in the US.

**Description**
- tall, erect grass with cane-like stems (1.8-3.5 m)
- produces broad leaves, up to 80 cm long
- spreads by short rhizomes (underground stems) spread to form a clump about 1 m across
- extensive, deep root system.
Sub-tropical grasses

**Perennial pastures for Western Australia**

**Sub-tropical grasses**

**Elephant grass**

Soil–climate adaptation

Rainfall (est.): >650 mm (particularly summer moist soils)

Drought tolerance: Moderate

Frost tolerance: Sensitive

Soil type: Adapted to moist, fertile soils

Soil fertility requirements: High, very responsive to N fertiliser

Soil pH<sub>Ca</sub>: >4.3 (est.)

Aluminium tolerance: Unknown

Waterlogging tolerance: Low to moderate

Salt tolerance: Unknown

Ability to spread naturally: Low (but forms large clumps)

Nutritive value

DMD: 70% (young leaves) declines rapidly with age to <55%<sup>393</sup>

Crude protein: 5.9-15.1%<sup>399</sup>

Environmental benefits

Soil erosion control: Used as a windbreak

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**Humidicola** (*Urochloa humidicola*)

Humidicola is a low growing, stoloniferous grass which forms a tight sward. It is tolerant of waterlogging and very acid soils (pH<sub>Ca</sub> >4.0), but has low drought and frost tolerance. It has moderate feed quality (DMD: 68 (54-75)%<sup>106</sup> and crude protein: 6.9-11.7% when N fertiliser increased from 0 to 150 kg/ha).<sup>306</sup> It is slow to establish under WA conditions. From very limited testing in WA, humidicola may be an alternative to kikuyu on acid soils in coastal districts (rainfall >600 mm) but otherwise appears to have few advantages over kikuyu.
**Paspalum (Paspalum dilatatum)**

**Features**
- slowly creeping, sward-forming grass
- highly tolerant of grazing
- very good late spring-early summer growth
- moderate drought tolerance
- seed heads susceptible to ergot infection.

Paspalum (or Dallis grass) is a summer-active perennial grass native to the humid sub-tropics of southern Brazil, Argentina and Uruguay. It is now widespread in many areas of the world and under suitable conditions is capable of very high production.\(^{359}\)

Paspalum was introduced into Australia in the late 19th century and was one of the first warm season grasses to be widely cultivated. In WA it was first sown in the irrigation areas and has now naturalised in disturbed moist areas, along irrigation channels and in lawns from Kalbarri to Albany.\(^{162}\) It can be an invasive weed of clayspans.

Paspalum has relatively small seeds (570-700,000/kg) and should be sown no more than 10 mm deep. The suggested sowing rate is 2-5 kg/ha when sown alone.

In WA, paspalum is dormant in winter and grows actively from October to May, providing soil moisture is non-limiting. It grows rapidly in late spring and early summer and then opportunistically over summer if moisture is available. It will run to seed rapidly in summer and needs to be heavily grazed to prevent seeding. Palatability drops markedly in rank or old growth.

Paspalum can withstand heavy grazing due to its rhizomatous growth habit, but for high production it should not be grazed below 5-7 cm.\(^{38}\) Paspalum pastures can become sod-bound, so periodic renovation to maintain productivity and retain the annual clover content is recommended. The pasture can be cultivated in autumn and then if required, re-sown with temperate species to provide the cool season growth.\(^{122}\)

**Description**
- tufted perennial grass with short rhizomes
- leaves are 7-40 cm long, flat and hairless with a distinct mid-rib and often wrinkled along the leaf margins
- seed heads have 4-6 lateral spikes on stems 0.6-1.5 m tall
- spikes are usually 4-10 cm long with a double row of spikelets along one side.
Sub-tropical grasses

Seed heads can be infected with ergot (*Claviceps paspali*) a dark-coloured, sticky fungus that can poison stock. Animals grazing affected pastures can develop ‘paspalum staggers’. Poisoned animals that are removed from the infected pasture at an early stage can recover within a few days. To control the disease, graze hard in summer to prevent seeding, or mow to remove the seed heads.

Paspalum has moderate drought tolerance, so is not confined to irrigated pastures. The role for paspalum in WA is mainly for soils that remain moist in summer and in southern coastal districts, either as part of a pasture mix or sown alone.

**Cultivars**

‘Common’ paspalum is the only type available.

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**Soil–climate adaptation**

**Rainfall (est.):** >600 mm plus summer moist sites

**Drought tolerance:** Moderate

**Frost tolerance:** Moderate, underground root-stocks allow it to recover from frosts

**Soil type:** Grows on sands to clays, but prefers fertile soils

**Soil fertility requirements:** Moderate

**Soil pH:** >4.3 (est.)

**Aluminium tolerance:** Unknown

**Waterlogging tolerance:** Moderate to high

**Salt tolerance:** Nil

**Ability to spread naturally:** Slowly by rhizomes and seed

**Nutritive value**

**DMD:** 56.7-58.4% (monthly cuts), 68.1% (leaf), 59.8% (stem)

**Crude protein:** Av. 10.1% (range 5.7-12.9%)
Vetiver grass is widely distributed through Africa, India, Myanmar, Sri Lanka and south-east Asia. It is mainly used as a ‘living contour’, being planted on the contour to trap soil while allowing water to flow through. The coarse roots contain an aromatic essential oil (vetiver oil) which is used as a perfume. In India the roots are woven into coarse mats and hung up to scent the room.

A key feature of vetiver grass is the thick, strong root system which can potentially grow to a depth of 5 m, is able to penetrate compacted soil layers and has minimal lateral growth. The depth of root growth gives vetiver grass considerable drought tolerance. Vetiver is a tall, bunch grass which can reach a height of 2 m at maturity.

The minimum rainfall is >400 mm (est.) and it will grow on a range of soils from sandy duplex soils to clays. Vetiver grass tolerates extremes of pH (3-10), high aluminium, sodicity and moderate salinity. Vetiver grass tolerates high concentrations of metals like cadmium, lead, mercury and arsenic, so has been used in minesite rehabilitation. It is also tolerant of flooding and waterlogging. The nutritive value is adequate if new regrowth is grazed, but mature growth is coarse and has a low palatability.

The role for vetiver grass in WA is mainly limited to soil conservation and possibly to revegetate moderately affected saltland or acid sulphate soils. There have been limited small plantings to date in south-western WA.

Vetiver grass is planted vegetatively as ‘splits’, at about 1 m spacing in rows, often on the contour. It spreads slowly by short rhizomes to form a large clump. The only available type of vetiver grass is a non-seeding type, called ‘Monto’ (public variety).