Chapter 4
Temperate perennial grasses

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Perennial pastures for Western Australia

- high winter and spring growth rates
- summer-active temperate grasses can provide out-of-season green feed
- high nutritive value with correct management
- mostly suited to permanent pasture in the medium to high rainfall zones
- best grown on relatively fertile soils that have moisture at depth in summer
- most species require rotational grazing to persist
- need to be established like a crop with no weed competition
- best sown in autumn
- research has demonstrated that tall fescue (temperate) and phalaris can increase livestock production in summer and winter respectively
- companion legumes are essential for a productive pasture.

Pastures in southern Australia are based largely on introduced annual and perennial temperate species, including sown, productive species and volunteer species that are typically less productive or less nutritious, e.g. silver grass (*Vulpia* spp.). The sown species include several valuable temperate perennial grasses (also called ‘cool season’ or ‘C3’ grasses) that are widely grown in NSW, Victoria and Tasmania and to a limited extent in south-western Australia. The main species – cocksfoot (*Dactylis glomerata*), perennial ryegrass (*Lolium perenne*), phalaris (*Phalaris aquatica*) and tall fescue (*Festuca arundinacea*) were introduced during the nineteenth century. Veldt grass (*Ehrharta calycina*) was introduced much later from South Africa and is grown only in WA and South Australia.

Annual legumes are an essential component of a productive perennial pasture – temperate perennial grasses with subterranean clover
in summer in comparison to phalaris, perennial ryegrass, cocksfoot and annual pasture. In most years of the study, phalaris, perennial ryegrass and cocksfoot were dormant in summer and therefore livestock only had access to dry residues.

In addition to increasing livestock production, it is important that perennial pastures help prevent land degradation, especially dryland salinity and soil erosion. To reduce the spread of salinity, perennial pastures need to use more water than the annual pastures. High water-use perennial pastures are characterised by deep root systems and green leaf in summer. Most of the common temperate grasses have relatively shallow root systems, particularly perennial ryegrass and cocksfoot and possess little or no green leaf in summer as they are typically summer-dormant (e.g. phalaris, perennial ryegrass, cocksfoot, winter-active tall fescue).

Studies in WA have demonstrated that phalaris can use more water than annual pastures particularly in the medium rainfall zone. However, in eastern Australia water-use by phalaris in high rainfall environments (>600 mm) was similar to annual pastures.

Two species that could use substantially more water than annual pastures are tall fescue (temperate, summer-active types) and veldt grass as both can grow actively in summer. Preliminary data on rooting depth of tall fescue suggest it is a high water-use species.

Why grow temperate perennial grasses?
Grasses are productive under grazing because the growing tip is located at the base of the plant and therefore remains protected during grazing. Grasses are suitable companion plants to legumes and consistently increase the yield of legume-dominant pastures through their use of previously fixed legume nitrogen. Their presence also provides livestock with a more varied diet. Research suggests that a mixed sward may provide animals with a more balanced diet, increase intake, reduce stress and increase feed-use efficiency.

Temperate grasses are particularly suited to permanent pasture and when well managed maintain a more desirable pasture balance compared to annual swards (Figure 4.1). The varying botanical composition of annual pastures is associated with the pattern of the opening rains and/or amount of seed set the previous spring. Perennial grasses depend little on seed set and germination and are therefore more stable across years. In addition, perennial grasses displace broad-leaf weeds resulting in a pasture with a low weed burden (Figure 4.1).
Temperate and sub-tropical grasses

There is a role for both temperate and sub-tropical grasses. The advantages of temperate grasses over sub-tropical grasses include:

- As a group they have higher nutritive value (Figure 4.2). Temperate grasses generally have a higher dry matter digestibility, due primarily to a lower lignin content.
- Superior winter-activity. The optimum temperature for growth of temperate grasses is about 20°C, while for sub-tropical grasses it is much higher (25-35°C). Consequently, temperate grasses grow actively in winter when sub-tropical grasses are dormant or at best growing slowly.
- Good persistence over winter. There is a ‘cold zone’ where the persistence of most sub-tropical grasses is adversely affected by the combination of cold, wet soils and frosts (Figure 5.1). Recent trials have demonstrated that the temperate perennial grasses are persistent and highly productive in this area.2 As a result there is a large potential for temperate perennial grasses to be grown widely in the medium to high rainfall (>550 mm) areas of this ‘cold zone’, which is largely used for growing pastures with only a small proportion under crop.

Figure 4.2 Annual profiles of metabolisable energy and % crude protein for grazed tall fescue, perennial ryegrass, cocksfoot, phalaris and subterranean clover in south-western Australia129
Summer-active temperate grasses increase the period of green feed allowing producers to reduce supplementary feed and/or increase the stocking rate. However, in hot moisture-limiting conditions many sub-tropical grasses show less signs of wilting than the temperate grasses. They are more water efficient under hot, dry conditions as they use the ‘C4 photosynthetic pathway’ (Chapter 5). As a consequence, the dry matter production of sub-tropical grasses declines less than temperate grasses when subject to high temperatures and moisture stress.

Under ideal conditions in summer with prolonged wet soils, sub-tropical grasses can be substantially more productive than temperate grasses, however in south-west WA these conditions are not common.

Where would you grow temperate perennial grasses?
Temperate grasses are best suited to permanent pasture in the medium to high rainfall zone or in paddocks that are uneconomic to crop in mixed farming areas. However, recent research from NSW has demonstrated that perennial grasses, including temperate species, can be incorporated successfully into phased rotations with wheat without affecting grain yield. In the absence of a legume for crop rotations perennial grasses may be an option, albeit one that may reduce grain protein.

The length of the growing season (Figure 1.3) is a reliable guide as to where temperate perennial grasses can be grown successfully. For the main species (except for veldt grass) the minimum growing season required is 6-6.5 months for winter-active types and 6.5-7 months for summer-active types.

In general, the temperate grasses are best grown on relatively fertile soils that have plant available soil moisture at depth outside the growing season. Exceptions are cocksfoot and veldt grass, which can be successfully grown on infertile soils. There are temperate grass options for both acid soils and waterlogged soils.

Temperate perennial grasses can be established successfully in the higher rainfall areas of the central and northern agricultural regions. However, their persistence is adversely affected by the high summer temperatures and the short growing season (<5.5 months) in these regions. In marginal environments there is typically a strong ‘edge effect’ in field trials, with plants on the outside of plots growing well due to access to more soil water. Therefore, in marginal environments use a wide row spacing (~50 cm) to increase the soil volume available to the plants.

Out-of-season production of temperate grasses is improved substantially with summer rainfall and mild summer temperatures, e.g. the south coast. In environments with a short growing season and little or no summer rainfall, temperate grass growth is restricted largely to the annual growing season. As a result, the seasonal feed supply is similar to that of annual pastures, but with higher production in autumn and early to mid-winter (i.e. for winter-active cultivars).

Refer to the individual species descriptions for their specific requirements.
Establishment

The first objective when planting perennial grasses is to achieve an adequate seedling density at emergence. The second is to ensure the survival of these seedlings through the first summer. With the exception of cocksfoot and veldt grass there is little evidence of seed recruitment by temperate grasses after the initial establishment, so the highest perennial plant density will be that following germination. Second year management should focus on the development of a strong crown and root structure. In general, plant density will decline over time, but this can be offset by larger plants with more growing points or tillers.

Site preparation

The philosophy should be to treat the pasture the same as a crop. This means controlling annual weeds, meeting nutrient requirements and possibly controlling drainage. Perennial grass seedlings are poor competitors and can be swamped by annual weeds, particularly annual grasses, as there are very limited post-emergence herbicide options. Annual grass control (e.g. annual ryegrass, barley grass) needs to start in the previous spring. Use minimum tillage to reduce soil disturbance and exposure of buried, dormant seeds to germination. Control of other perennial broad-leaf weeds (e.g. dock) may need to commence two years before planting.

Sowing perennials into a previously cropped paddock is a useful way of reducing weed competition, but in practice areas suitable for annual crops are unlikely to be sown to perennial pastures. However, cropping the target area the year before sowing perennial grasses can reduce specific weeds. Cropping can also help clean up and level paddocks ready for future fodder conservation. In areas with fragile sandy soils, crop stubbles help reduce the risk of erosion at seeding. However, a drawback is the depletion of annual clover seed reserves.

Time of sowing

Given adequate weed control, temperate perennial grasses are best sown in autumn. This gives the plants a longer period to develop a strong root system before summer and gives them a better chance of surviving the first summer. Seeding should be two to three weeks after the break of season (longer in non-wetting sandy soils) as this allows for a good germination of annual weeds, which can then be removed with a non-selective herbicide before seeding. It is important not to compromise weed control at this stage.

Seeding objectives

Three requirements when sowing perennial grasses are:

- **Accurate delivery rate of seed.** If the seeding machine cannot handle the delivery of small quantities of small seeds, mix the seed with coarse sand or superphosphate at seeding. However, avoid storing it in this form.
- **Accurate seeding depth.** Accurate seed placement (up to 10 mm) is achieved best by using machines with independent floating tyne or disc assemblies, each unit being able to maintain a constant seeding depth. Using conventional machines with relatively rigid tyne assemblies on uneven or sandy soils can result in a variable seeding depth and patchy emergence.
- **Minimal soil disturbance.** Covering weed seeds will stimulate their germination while spring sowing on sandy soils will increase the risk of wind erosion. Minimal disturbance can be achieved using narrow pointed tynes, inverted T-tynes or triple disc assemblies, ideally followed by press wheels as rolling will enhance seed germination.

Sowing mixtures of perennial grasses

Sowing mixtures of temperate grasses can make better use of soil variation and achieves a more even feed supply. When sowing mixtures remember that seed numbers per kilogram are likely to be different and that species could have different competitive characteristics as seedlings. For example, sowing a mixture of 3 kg/ha each of cocksfoot and tall fescue delivers more than three times as many cocksfoot seeds as tall fescue seeds. In addition, tall fescue seedlings are weak competitors so the pasture is likely to become dominated by cocksfoot. To overcome these problems sow the different species in alternate rows or sow one species across the paddock and the other at a 90 degree angle. Alternatively, adjust the sowing rate based on the number of seeds per kilogram and percentage germination to give the desired proportion of each species.
Management after sowing

Insect control
Redlegged earth mites (RLEM) are normally associated with silvering of subterranean clover cotyledons and leaves, so damage to other sward components is often overlooked. When perennial grass seedlings make up most of the available green material they can easily be destroyed by RLEM. Carefully check emerging pastures regularly for the presence of insect pests (e.g. RLEM, webworm, cutworm and cockchafers) and control as necessary. Failure to apply sprays could result in poor or failed establishment.

Early grazing management
In the establishment year, careful grazing management is required. Pastures should not be grazed before they reach 1200 kg/ha of feed-on-offer (FOO) and ideally the pastures should enter summer with 2500-3000 kg/ha FOO. This allows the grasses to develop to a reasonable size and store reserves for the first summer.

Grazing management
The key objectives of grazing management are to optimise pasture growth, maintain pasture composition in a desirable state, use pasture efficiently, meet livestock goals and prevent land degradation.

Pasture growth depends on water, nutrients, carbon dioxide and sunlight. Producers have some control over the amount of sunlight that is intercepted by pasture through the impact of grazing on leaf area. In general, the higher the leaf area the higher the potential growth (refer to kikuyu example Figure 2.1).

The grazing management of temperate grasses also needs to focus on persistence because the majority do not recruit new plants (cocksfoot is an exception). To persist, all species require rest from grazing because:

- continuous grazing damages either the base of tillers or dormant buds
- during the reproductive or regeneration phase grazing further depletes already low plant reserves and increases plant death.

Rest is of particular importance in summer when growth has ceased and excess FOO has been removed via grazing. The type of livestock also influences persistence. All of the temperate grasses persist when continuously grazed by cattle at modest stocking rates, but decline under sheep (Figure 4.3).

The key to grazing management from the plant’s perspective is to understand the biology of the particular species. For example, phalaris is particularly sensitive to repeated or continuous heavy grazing or cutting in spring.

For further discussion of grazing management refer to the individual species descriptions.

Livestock production
There have been few comparisons of livestock production on temperate perennial grasses in WA. In addition, some of the studies used set-stocking which could have adversely affected both the persistence and production of the perennial grasses.

The performance of sheep grazing subterranean clover-based pastures with and without temperate perennial grasses (phalaris, cocksfoot, perennial ryegrass and tall fescue) was compared at two sites in the 500–550 mm rainfall environment under set-stocking. Including perennial grasses tended to reduce liveweight losses during autumn.
and early winter with the most consistent results being obtained on phalaris and tall fescue. Significant differences were also found in wool production (Table 4.1). Sheep grazing tall fescue and phalaris averaged fleece weights of 0.29-0.76 kg/head higher than sheep on annual pasture. The perennial ryegrass density declined rapidly under set-stocking with <1 plant/m² remaining at the end of the experiment.

The performance of steers on temperate perennial pastures was compared with an annual pasture control at two sites in a high rainfall environment (600-800 mm). At Mt Barker Research Station perennial grasses reduced the need for hay supplements by 20 to 67% (Table 4.2). Across the four years of the study the average additional liveweight gain over the annual pasture control was 39, 46 and 97 kg/ha for cocksfoot, tall fescue and phalaris respectively (Table 4.2 for annual results). The pattern of steer growth varied between the different perennial species, with those grazing cocksfoot and tall fescue performing slightly better in late summer and autumn while those grazing phalaris grew faster in winter and spring. Steers on perennial ryegrass consistently lost more weight in autumn and were unable to make up the loss in the winter and spring.

At Pardelup Prison Farm, tall fescue (temperate) gave superior animal production to cocksfoot, phalaris and perennial ryegrass, particularly during the out-of-season feed gap. Over the duration of the experiment the average additional liveweight gain compared with the annual pasture control was 9, 47 and 28 kg/ha for cocksfoot, tall fescue and phalaris respectively (Table 4.2). Similar to Mt Barker Research Station, steers grew well on phalaris during spring. Perennial ryegrass failed to perform better than the annual pasture and was replaced with kikuyu in late 1993. When feed ran out on the experimental plots in autumn steers were agisted elsewhere on the farm. Steers grazing the annual pasture were agisted for an average of 43 days, those on cocksfoot for 19 days and those on phalaris for 29 days, while no agistment was required for steers grazing tall fescue (Table 4.2).

There are no experimental comparisons between veldt grass and annual pasture, but anecdotal evidence suggests that a pasture comprising veldt grass with serradella can provide valuable summer feed and increase livestock production.

In summary, limited research in WA suggests that introducing phalaris and tall fescue into an annual pasture can increase livestock production, phalaris in winter/spring and tall fescue (temperate) in summer/autumn. Given the high value of pasture in summer and autumn, the temperate tall fescue is likely to be the more profitable option.

### Table 4.1 Average fleece weights (kg/head) for Merino wethers on temperate perennial grasses at Kojonup and Takalarup between 1968 and 1974 (set-stocked at 10 DSE/ha)

<table>
<thead>
<tr>
<th>Location</th>
<th>Year</th>
<th>Phalaris CPI 14697</th>
<th>Cocksfoot cv. Currie</th>
<th>Perennial ryegrass cv. Kangaroo Valley</th>
<th>Tall fescue cv. Melik</th>
<th>Annual pasture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kojonup</td>
<td>1968–69</td>
<td>5.94a</td>
<td>4.64b</td>
<td>4.19c</td>
<td>4.10c</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1969–70</td>
<td>4.94a</td>
<td>4.73a</td>
<td>4.29ab</td>
<td>3.85b</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Takalarup</td>
<td>1972</td>
<td>4.51a</td>
<td>3.97bc</td>
<td>4.04bc</td>
<td>4.32ab</td>
<td>3.82c</td>
</tr>
<tr>
<td></td>
<td>1973</td>
<td>5.38a</td>
<td>4.71b</td>
<td>4.94ab</td>
<td>5.28a</td>
<td>5.20ab</td>
</tr>
<tr>
<td></td>
<td>1974</td>
<td>4.21ab</td>
<td>4.17b</td>
<td>4.29ab</td>
<td>4.47a</td>
<td>4.18b</td>
</tr>
</tbody>
</table>

1 In any one year fleece weights not followed by a common letter differ significantly.
Table 4.2 Liveweight gains for steers on pastures at Mt Barker Research Station and Pardelup Prison Farm between 1993 and 1996 (stocked at 1.5 steers/ha)

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Measurement</th>
<th>Annual pasture</th>
<th>Cocksfoot cv. Currie</th>
<th>Perennial ryegrass cv. Brumby</th>
<th>Tall fescue cv. Au Triumph</th>
<th>Phalaris cv. Sirosa</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>Mt Barker Research Station</td>
<td>Liveweight gain</td>
<td>489 (100%)¹</td>
<td>566 (116%)</td>
<td>436 (89%)</td>
<td>573 (117%)</td>
<td>587 (120%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hay or grain fed</td>
<td>343</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Pardelup Prison Farm</td>
<td>Liveweight gain</td>
<td>409 (100%)</td>
<td>499 (122%)</td>
<td>400 (98%)</td>
<td>504 (123%)</td>
<td>492 (120%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Agistment period (days)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1994</td>
<td>Mt Barker Research Station</td>
<td>Liveweight gain</td>
<td>377 (100%)</td>
<td>419 (111%)</td>
<td>337 (89%)</td>
<td>426 (113%)</td>
<td>488 (129%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hay or grain fed</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Pardelup Prison Farm</td>
<td>Liveweight gain</td>
<td>319 (100%)</td>
<td>285 (89%)</td>
<td>–</td>
<td>322 (101%)</td>
<td>255 (80%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Agistment period (days)</td>
<td>84</td>
<td>20</td>
<td>–</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>1995</td>
<td>Mt Barker Research Station</td>
<td>Liveweight gain</td>
<td>377 (100%)</td>
<td>411 (109%)</td>
<td>318 (84%)</td>
<td>402 (107%)</td>
<td>486 (129%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hay or grain fed</td>
<td>329</td>
<td>137</td>
<td>400</td>
<td>168</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Pardelup Prison Farm</td>
<td>Liveweight gain</td>
<td>336 (100%)</td>
<td>333 (99%)</td>
<td>–</td>
<td>346 (103%)</td>
<td>381 (113%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Agistment period (days)</td>
<td>46</td>
<td>36</td>
<td>–</td>
<td>0</td>
<td>39</td>
</tr>
<tr>
<td>1996</td>
<td>Mt Barker Research Station</td>
<td>Liveweight gain</td>
<td>317 (100%)</td>
<td>320 (101%)</td>
<td>211 (67%)</td>
<td>343 (108%)</td>
<td>387 (122%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hay or grain fed</td>
<td>1195</td>
<td>249</td>
<td>859</td>
<td>299</td>
<td>597</td>
</tr>
<tr>
<td></td>
<td>Pardelup Prison Farm</td>
<td>Liveweight gain</td>
<td>228 (100%)</td>
<td>208 (91%)</td>
<td>–</td>
<td>306 (134%)</td>
<td>277 (121%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Agistment period (days)</td>
<td>41</td>
<td>41</td>
<td>–</td>
<td>0</td>
<td>55</td>
</tr>
</tbody>
</table>

¹ Liveweight gain relative to annual pasture control.
² Due to loss of perennial ryegrass plants this pasture had reverted to an annual pasture by 1994.
regrowth in autumn. Winter-active phalaris uses this strategy and following flowering the leaves senesce and the plant dies back to the dormant vegetative buds, while the shallow roots die when the surface soil dries out, leaving a deep root system to maintain adequate moisture for the living tissue. Following autumn rains the buds break dormancy and develop into new tillers.

Summer-dormant temperate grasses persist in WA with good management, however they rarely provide high value green feed in summer or reduce groundwater recharge to the same extent as summer-active temperate grasses. On the other hand, summer-activity can compromise persistence particularly in marginal rainfall environments. For example, summer-dormant tall fescue is more persistent than summer-active cultivars under grazing at Hamilton, Victoria. One suggested approach is to grow summer-active and summer-dormant types together to provide a more even distribution of feed throughout the year while maintaining good persistence.

When selecting a temperate grass consideration needs to be given to summer activity vs. summer dormancy, the time(s) in the year the pasture is required to provide feed and how long the pasture needs to persist. In medium rainfall environments (<6.5 month growing season) the moderately to highly summer-dormant types are often the only option with the exception of veldt grass. In high rainfall (>600 mm) areas along the south coast the summer-active types will often perform well.

**Endophytes + temperate perennial grasses**

Kevin Reed

This section discusses using grass endophyte technology to improve the performance of perennial grasses. Cultivars of perennial ryegrass and tall fescue which contain ‘novel’ or safe endophyte are now available. The use of safe endophyte can improve plant persistence under stressful conditions and provide some resistance to insect attack while presenting minimal risk to livestock.

**Background**

Old naturalised populations of perennial ryegrass in eastern Australia are infected with the endophyte, *Neotyphodium lolii*, a microscopic fungus living entirely between the plant cells. Toxic alkaloids produced by the fungus cause perennial ryegrass toxicosis, a disorder associated with heat stress and animal production losses and with which some livestock exhibit staggers and may die. Livestock problems have led some farmers to use seed of endophyte-free grass. (Note: the cause and effect of ‘ryegrass staggers’ is distinctly different to ‘annual ryegrass toxicity’.)
Similarly, a different endophyte (N. coenophialum) associates with tall fescue and causes fescue toxicosis. However, unlike the situation with perennial ryegrass, old popular cultivars of tall fescue in Australia are free of endophyte.

Plant persistence and endophyte
The association between the grass and the endophyte is mutually beneficial. The association provides the fungus with food, a home and a means of reproduction. In return the fungus helps the grass host resist grazing herbivores, insect pests, nematodes and diseases. The fungus also helps the grass adapt to low nutrient and moisture limiting conditions.

Under stressful conditions, plants infected with endophyte show better persistence than endophyte-free plants. These differences are most evident when there the plants are subject to multiple stresses, e.g. the concurrence of pests and drought.

In Victoria, endophyte-free perennial ryegrass has shown poor establishment, less tillering and poor persistence in comparison with endophyte-infected perennial ryegrass (Table 4.3). Similarly, in tall fescue endophyte-free cultivars have shown poor establishment, less tillering and poor persistence in comparison with endophyte-infected cultivars.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Endophyte frequency (%)</th>
<th>Seedling density (plants/m²)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Victorian</td>
<td>0</td>
<td>105d**</td>
</tr>
<tr>
<td>Victorian</td>
<td>80</td>
<td>136cd</td>
</tr>
<tr>
<td>Ellett</td>
<td>1</td>
<td>151bc</td>
</tr>
<tr>
<td>Ellett</td>
<td>68</td>
<td>228a</td>
</tr>
</tbody>
</table>

* 400 certified, pure live seeds were sown per square metre
** means with a common letter do not differ \( P < 0.01 \)

Alkaloids produced by endophytes
There are many substances produced in varying amounts by different endophytes. Four substances are of current interest:

- **Lolitrem B** is a cause of ‘ryegrass staggers’ and is found in perennial ryegrass.
- **Ergovaline** is one of the ergot alkaloids which cause fescue toxicosis (which includes heat stress, summer ill thrift, reproductive problems and fescue foot). It occurs in both wild endophyte-infected perennial ryegrass and tall fescue. It also protects the plant against attack by some insects including African black beetle.
- **Peramine** can occur in both endophyte-infected perennial ryegrass and, to a small extent, in tall fescue. It has no known deleterious effects on livestock and helps to protect the plant against some insect attack.
- **Lolines** are found in tall fescue and some Loliump species, but not commonly in perennial ryegrass. They are potent insecticides and deter some insects (including some virus vectors/aphids) from feeding on plants.

Novel or safe endophyte
Cultivars of perennial ryegrass or tall fescue infected with a select/beneficial endophyte sometimes referred to as a novel endophyte are now available. These are developed by removing the common (or wild, natural) endophyte and replacing it with a genetically distinct strain of the same fungal species. The selected strain is one that has been identified as producing little or no livestock toxin but carries the defence capability so valuable to the plant when it faces the threat of drought or pest attack.

Beneficial endophytes inoculated into some cultivars of perennial ryegrass sold in Australia are known as AR1, AR5 and NEA2, while AR37 is being tested. It is estimated that about 10% of the perennial ryegrass seed sold in Australia in 2004 was endophyte-free, while a further 10% contained a beneficial endophyte.

Tall fescue with Max P endophyte which produces peramine and lolines but no ergovaline is showing promise in areas of NSW prone to African black beetle attack.
4.1 Cocksfoot (*Dactylis glomerata*)

**Features**
- persistent, acid-tolerant perennial tussock grass
- mostly summer-dormant with high drought tolerance
- contains no substances harmful to animals
- does not tolerate waterlogging
- requires rotational grazing, particularly with sheep.

Cocksfoot is a tussock grass native to Europe, northern Africa and temperate Asia. It has been introduced to other temperate parts of the world including North and South America, South Africa, New Zealand and Australia because of its value as a pasture plant. Cocksfoot is valued throughout the world for its better persistence than perennial ryegrass on soils prone to drying out quickly and of moderate fertility.

In Australia, the area planted to cocksfoot has expanded, particularly in the eastern States, from the poorer and drier parts of dairy farms in the high rainfall zone to the sandy or shallow soils in wool producing areas with moderate rainfall.

Varieties of cocksfoot available in Australia can be classified into two main groups – ‘Mediterranean types’ with moderate to high summer dormancy and ‘intermediate types’ which are more summer-active.

**Establishment**
Cocksfoot possesses a small, very light seed averaging about 1.3 million/kg. It needs to be sown close to the surface at a depth of 10 mm or less on most soils. The suggested rate is 2-3 kg/ha when sown alone. A rate of 2.5 kg/ha gives about 240 viable seeds/m².

Cocksfoot is best sown in autumn. Early growth is slow, although it is generally more vigorous than phalaris and tall fescue.

**Livestock disorders**
Cocksfoot does not contain any substances harmful to animals.

**Description**
- tussock-forming perennial up to 1.5 m high with strongly flattened vegetative shoots
- greyish-green to green foliage, leaves are long (up to 80 cm) usually flat but may be folded lengthwise to give a shallow V-shaped cross-section
- white translucent ligules 2–10 mm long
- leaf sheaths very much flattened, hairless, prominent keel
- inflorescence is an erect one-sided panicle, 10–20 cm long, with the upper branches close together and the lower ones more widely spaced. The spikelets are in dense clusters at the end of the branches.
Management
When cocksfoot seedlings are sufficiently anchored in the ground (six to eight months after sowing) they can be lightly grazed to promote tillering and stimulate crown formation. Cattle are preferred for this task but if only sheep are available, graze for short durations to prevent defoliation of young plants. Rotationally graze to maintain a height of about 5-7 cm (about 1500-2000 kg DM/ha). If plants are stressed, then graze lightly or delay grazing until after flowering.

Cocksfoot can persist well with proper management, particularly under cattle. Established swards are best managed with rotational grazing however they can tolerate set-stocking during winter and spring. The best grazing management is one that prevents over-grazing and minimises grass content in summer and autumn to maintain vigorous growth and a good legume density. The pasture should be maintained at about 1000-2500 kg DM/ha, i.e. around 3-8 cm in height.

Cocksfoot stands can thin out quickly under sheep if not carefully managed, particularly during hot dry summers. However, if grazing is controlled cocksfoot can persist. Avoid heavy close grazing that damages the crown of the plant or lax grazing that produces tall, rank growth of low digestibility.

Cocksfoot responds to increasing soil fertility. New sowings require fertiliser to promote early root development and enhance seedling vigour. Mature stands should have major deficiencies corrected on the basis of soil tests. Cocksfoot, like all grasses, responds to nitrogen either via a companion legume or fertiliser application. It makes good quality hay or silage.

Companion species
Cocksfoot combines well with subterranean clover, lucerne and serradella.

Soil–climate adaptation
Rainfall: >500 mm (south coast >425 mm)
Season length: >6 months
Drought tolerance: High
Frost tolerance: Moderate
Soil type: Well-drained, sand or loam over clay or gravel
Soil fertility requirements: Moderate
Soil pH: >4.0
Aluminium tolerance: Moderate
Waterlogging tolerance: Low
Salt tolerance: Nil
Nutritive value
DMD: 53-79%
ME: 7.3-11.3 MJ
Crude protein: 8.5-27.8%

Environmental benefits
Cocksfoot’s groundwater recharge control is poor as it does not have a deep root system. Most of the roots die back over summer and then regrow in autumn.
Cultivars
While most of the cocksfoot cultivars have been available for many years, recently the Department of Primary Industries in collaboration with the University of Tasmania released three new varieties.

The cultivars can be grouped according to their relative growth in winter and summer, which reflects their origins from the Mediterranean region (winter-active, summer-dormant) to temperate Europe (low winter growth, summer-active).

Mediterranean type, moderate to high summer dormancy
‘Kasbah’ (public variety) – has good growth from late autumn to mid-winter but growth in late winter and spring is poor. Kasbah flowers in early September, about one month earlier than Currie. This variety is highly summer-dormant and survives summer drought better than Currie. It is useful in dry locations for short-term rotations.

‘Sendace’ – is a new variety developed in Tasmania from germplasm collected in Spain with good drought and cold tolerance. It has a prostrate to semi-erect growth habit with a high tiller density and moderate to high summer dormancy.

‘Uplands’ – is a new variety developed in Tasmania from germplasm collected in Spain.

Intermediate type, summer-active
‘Cambria’ (public variety) – a new variety with year-round production.

‘Grasslands Kara’ – was bred in New Zealand to replace Grasslands Apanui. Improved winter growth and disease resistance. Upright growth habit more suited to cattle than sheep. For persistence it should be rotationally grazed. Flowers about three weeks later than Porto. It is suited to dryland dairy production and high rainfall beef enterprises.

‘Grasslands Tekapo’ (public variety) – replacement for Grassland Wana was bred for improved nutritive value. It has moderate drought tolerance but in field evaluation in WA had lower persistence than Currie or Porto.

‘Grasslands Vision’ – was selected by crossing Grasslands Kara with Grasslands Wana. The morphology is intermediate between the parents, although more like the erect Kara than the prostrate Wana. Grasslands Vision is intended for use on dairy farms and is slightly more persistent and productive than Kara.

‘Megatas’ – a new summer-active variety developed in Tasmania.

Cocksfoot (foreground) has good persistence in dry summers providing it is not grazed heavily.

It has a semi-erect to erect growth habit and moderate summer dormancy similar to Currie.

‘Currie’ (public variety) – derived from germplasm collected in Algeria. Persistent and productive and grows well from autumn through to spring. Summer growth depends on rainfall and temperature. Persists well on sandy soils.

‘Porto’ (public variety) – derived from germplasm collected in Portugal. Porto is more productive than Currie, particularly in autumn and winter but is less drought-tolerant. Matures about one week later than Currie. Good potential production in summer if moisture is available.
Perennial pastures for Western Australia

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Temperate perennial grasses

4.2 Perennial ryegrass (*Lolium perenne*)

**Features**

- highly nutritious and palatable perennial grass
- with good management can be very productive in suitable environments
- excellent seedling vigour
- high temperatures constrain summer growth
- low drought tolerance, so best suited to fertile soils (>600 mm)
- requires rotational grazing for persistence, high yields and to maintain nutritional quality.

Perennial ryegrass is one of the most valuable pasture grasses for temperate regions of the world. It is a native of Europe, temperate Asia and north Africa and was introduced into Australia in 1803. Under favourable conditions perennial ryegrass can produce large amounts of high quality feed throughout the growing season. It grows predominantly from the autumn break until late spring, but can make useful growth in summer if it receives substantial amounts of out-of-season rainfall or irrigation. Summer growth is restricted by high temperatures (>30°C), even if sufficient moisture is available. Perennial ryegrass has low drought tolerance and a relatively shallow root system. As a result, its role in WA is limited to fertile soils in high rainfall areas and irrigated pastures.

**Seasonal growth pattern**

![Growth Chart](image)

**Description**

- tussock-forming perennial up to 60 cm in height with a fibrous root system
- dark-green foliage, leaf blades are hairless, flat, upper surface evenly ribbed, lower surface smooth and shiny. Length to 30 cm, width to 7 mm. Young leaves normally folded in the bud, with a V-shaped cross-section
- ligule membranous, white, transparent, shorter than wide. Auricles small and narrow
- leaf sheath hairless with fine longitudinal ribs as in leaf blades, base of sheath may be reddish-purple
- inflorescence is an erect narrow spike up to 20 cm long to which the spikelets are attached alternately, on opposite sides of a wavy stalk.
Soil–climate adaptation

Rainfall (est.): >600 mm
(south coast >500 mm)\(^{129}\)

Season length: >8 months\(^{129}\)

Drought tolerance: Low\(^{241}\)

Frost tolerance: High\(^{241}\)

Soil type: Well-drained medium- to fine-textured. Coarse-textured soils tend to dry out too much during summer\(^{241}\)

Soil fertility requirements: High\(^{241}\)

Soil pH\(_{Ca}^+\): >4.0

Aluminium tolerance: Sensitive (but varies with cultivars)\(^{430}\)

Waterlogging tolerance: Low to moderate\(^{241}\)

Salt tolerance: Slight to moderate\(^{330}\)

Nutritive value

DMD: 56-85\%\(^{129}\)

ME: 7.8-12.3 MJ\(^{129}\)

Crude protein: 8.0-27.7\%\(^{129}\)

Environmental benefits

Groundwater recharge control: Low, as perennial ryegrass does not develop a deep root system.\(^{41}\) The roots are short-lived, with most dying over summer and regrowing the following autumn.

Establishment

Perennial ryegrass is relatively easy to establish due to its excellent seedling vigour, however it is still necessary to minimise weed competition.\(^{363}\) It should be sown into a prepared seedbed or direct drilled at 6 kg/ha which should give about 240 viable seeds/m\(^2\) based on 530,000 seeds/kg and a minimum germination rate of 75\%.\(^{128}\) It is best not to sow other perennial grasses with perennial ryegrass due to its highly competitive nature.

Perennial ryegrass is sown in autumn no deeper than 10 mm.

Livestock disorders

A disorder called ‘ryegrass staggers’ can occur in livestock grazing perennial ryegrass in late summer and early autumn. Stock often appear normal until moved, when they usually exhibit a high-stepping gait and may collapse in severe spasm. Young stock are generally more susceptible than older ones. Symptoms usually begin 7-14 days after the animals have been placed on toxic pasture.\(^{194}\)

The condition is caused by the endophyte fungus (\textit{Neotyphodium lolii}), which produces the toxic compound lolitrem B.\(^{62}\) If ryegrass staggers occurs stock need to be moved quietly to a non-toxic area and/or given supplementary feed. The ‘do-nothing’ approach is also viable as most stock recover.\(^{194}\) The endophyte causes a range of animal problems including reduced growth rates and milk production.\(^{62}\) Endophytes can be eliminated by storing seed at 20-25°C for 18-24 months.\(^{363}\)

Management

The first grazing of perennial ryegrass should be delayed until seedlings are firmly established and feed-on-offer has reached about 1800 kg DM/ha to avoid stock pulling plants out of the ground.\(^{241}\)

\[\text{Autumn growth of perennial ryegrass at Kojonup}\]
Temperate perennial grasses

Perennial ryegrass–subterranean clover pasture in winter

Use a heavy stocking rate for a short period to promote the development of new tillers and graze down to ~1200 kg DM/ha. Remove dry residues from established stands of perennial ryegrass during autumn to encourage new tillers. But do not graze too hard during this period – rotationally graze if possible to keep feed-on-offer (FOO) >1200 kg DM/ha. In winter, continue rotational grazing and maintain FOO between 1200 and 2000 kg DM/ha. Most tillering is initiated during autumn and winter and the yearly production is largely reliant on management during this period.

In spring, maintain between 1600 and 3000 kg DM/ha while continuing to rotate stock. To increase plant density, reduce the stocking rate to enable a more plants to set seed. Aim to have between 2000 and 3000 kg DM/ha at the end of spring to protect the soil surface and provide feed for stock during summer. In summer do not graze hard or allow FOO to fall below 1500 kg DM/ha. Do not set-stock perennial ryegrass stands affected by moisture or heat stress otherwise plant death will occur. Pastures should be rested in areas with mean summer temperatures >30°C.

An alternative management approach is to allow plants to develop three leaves per tiller, graze intensively for a short period and then move stock on. Preventing the plant going beyond the three-leaf stage maximises pasture production and quality.

N and P levels can influence perennial ryegrass productivity and persistence significantly. Ideally N should be provided via a companion legume, however autumn and winter growth can be improved with fertiliser N in autumn (25 to 50 kg N/ha). Maintain soil phosphorus levels around a Cowell P of 30 ppm.

In a pasture mix with clovers, perennial ryegrass makes good quality hay or silage. The best time to cut hay is in the early flowering stage, as after this the nutritive value quickly declines.

**Companion species**

It is compatible with most pasture legumes including subterranean clover, serradella, lucerne and perennial lotus. It is compatible with other temperate perennial grasses such as tall fescue, phalaris and cocksfoot, however the companion species need to be sown in separate rows or the more vigorous perennial ryegrass seedlings will dominate the sward.

**Cultivars**

There are many cultivars of perennial ryegrass available in Australia. These can be grouped according to their maturity and number of chromosomes – very early maturing diploids, early maturing diploids, mid-late season diploids and late season tetraploids. The mid- to late-season diploids and tetraploids are suited to regions such as south-west Victoria with fertile soils, high rainfall, long growing seasons and mild summers, so are less suited to WA.
Most (~70%) perennial ryegrass seed sold in Australia contains endophyte, but some varieties are now available with ‘novel’ endophyte or are free of endophyte. The ‘wild’ endophyte produces three main chemicals: peramine, lolitrem B (causes ryegrass staggers) and ergovaline (toxin that can reduce animal performance). The novel endophyte AR1, produces peramine to provide some insect resistance but produces no ergovaline or lolitrem B.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very early maturing diploids</strong></td>
<td></td>
</tr>
<tr>
<td>’Boomer’</td>
<td>Kangaroo Valley type with good winter growth and drought tolerance. Suitable for sheep and cattle production.</td>
</tr>
<tr>
<td>’Fitzroy’</td>
<td>Kangaroo Valley type selected for high winter production, reduced rust and improved persistence by Agriculture Victoria. Suitable for sheep and cattle pastures (including dairy), in marginal dryland areas.</td>
</tr>
<tr>
<td>‘Kangaroo Valley’ (public variety)</td>
<td>Old Australian ecotype. One of the earliest maturing perennial ryegrass cultivars with strong growth in autumn, winter and early spring. Contains both erect and prostrate types. Variable rust resistance. Suitable for sheep and cattle grazing. Persistent, but now replaced by newer varieties with Kangaroo Valley parentage such as Boomer and Fitzroy which are tolerant of drier conditions. Suited to areas with an annual rainfall &gt;700 mm or where irrigation is available.</td>
</tr>
<tr>
<td>’Matilda’ (public variety)</td>
<td>Kangaroo Valley type, very early maturing cultivar with good winter and spring growth. Rust resistant. Suitable for sheep and cattle pastures.</td>
</tr>
<tr>
<td>’Meridian’</td>
<td>A cross combining the very early maturity and higher winter production of Kangaroo Valley with the performance of Yatsyn 1. Good persistence. Particularly suited to dairy systems with early calving and winter milking. Early seeding under harsh summer conditions ensures persistence.</td>
</tr>
<tr>
<td>’Meridian Plus AR1’</td>
<td>As for Meridian, but with novel endophyte that retains insect resistance while reducing incidence of ryegrass staggers.</td>
</tr>
<tr>
<td><strong>Early maturing diploids</strong></td>
<td></td>
</tr>
<tr>
<td>’Camel’</td>
<td>Persistent, more drought-tolerant variety, with good autumn and winter production. Suited to lower rainfall areas than other perennial ryegrasses. Bred from material collected from central Victoria. Suitable for sheep and beef cattle production.</td>
</tr>
<tr>
<td>’Ceres Kingston’</td>
<td>Bred for improved tolerance to acidic soils including soil aluminium. Tolerant to dry periods. Good autumn/winter growth. Mid-season maturity with average aftermath heading. Suitable for sheep and cattle grazing.</td>
</tr>
<tr>
<td>’Roper’</td>
<td>Selected from later maturing Kangaroo Valley types. Good winter and spring growth. Summer-dormant and has good drought tolerance. Moderate rust resistance. Suitable for sheep and cattle pastures.</td>
</tr>
<tr>
<td>’Victorian’ (public variety)</td>
<td>Old Australian cultivar widely used for many years but now being replaced by newer cultivars. Drought-tolerant, but susceptible to rust and yellow dwarf virus. Good growth in autumn and spring though less productive than most other cultivars. Possibly better adapted to hot dry summers and suitable for sheep grazing as well as cattle. An option for areas that are marginal for perennial ryegrass.</td>
</tr>
<tr>
<td><strong>Mid- to late season diploids</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Late season tetraploids</strong></td>
<td></td>
</tr>
<tr>
<td>’News’ (public variety), ’Quartet’</td>
<td>*’Matrix’ is a hybrid between perennial ryegrass and meadow fescue (Festuca pratensis), but is included as it has similar characteristics and management requirements to perennial ryegrass.</td>
</tr>
</tbody>
</table>
4.3 Perennial veldt grass (*Ehrharta calycina*)

**Features**
- productive, palatable tufted grass
- suited to infertile sandy soils including deep pale sands
- very high drought tolerance
- summer activity depends on seasonal conditions
- requires rotational grazing to persist
- widespread weed of roadsides, which can invade bushland.

Perennial veldt grass is native to South Africa where it thrives on sandy soils with an annual rainfall of 250-750 mm. It is thought to have been accidentally introduced to Australia via South African fodder purchased for the Perth Zoo. Perennial veldt grass then became naturalised on roadsides, vacant land and in parklands. The only registered cultivar ‘Mission’ was selected from this naturalised population. Today perennial veldt grass is an invasive weed of bushland and disturbed sites on sandy soils from Geraldton to Esperance. On farms it should not be sown near remnant bushland or nature reserves.

Perennial veldt grass is a hardy, productive and palatable grass especially suited to low fertility and sandy soils. It is most productive in autumn and spring but will also grow actively in summer if it has access to moisture. Perennial veldt grass has also become valued for its ability to stabilise drifting soils in harsh environments.

**Establishment**
Perennial veldt grass has a small seed (1,500,000/kg) and is sown in autumn at 2-3 kg/ha when planted alone. The recommended sowing depth is no more than 10 mm. Seedlings are slow to establish so it is important to ensure they are sown into a weed-free seedbed. On non-wetting sands, weed germination can be delayed because of the uneven wetting pattern. Ensure there is a full germination of the weeds before spraying and seeding. Furrow seeding can

**Description**
- tufted slender perennial, 30–75 cm high
- foliage is dull or blue-green, leaves are tinged purple and red or purple colouration also occurs where the leaf meets the stem
- leaves are pale, straight and lax, 2-9 cm long, flat or inrolled in cross-section, with wavy margins
- ligule is membranous, short, ragged and frayed with short hairs. Auricle present with a few hairs
- leaf sheath is tight and hairless
- inflorescence is a narrow but loose panicle, 7-22 cm long, with fine wavy branches, spikelets are red to purple and when mature hang down towards one side.
Perennial pastures for Western Australia

Temperate perennial grasses

Soil–climate adaptation

Rainfall (est.): >350 mm
(south coast >300 mm)
Season length: >4 months
Drought tolerance: Very high
Frost tolerance: Moderate (becomes dormant after heavy frosts)
Soil type: Deep sandy soils, including pale deep sands. Not usually suited to medium- to fine-textured soils, especially when surface is firm or hardsetting
Soil fertility requirements: Moderate, responsive to N
Soil pH, Ca: >4.0
Aluminium tolerance: Moderate
Waterlogging tolerance: Low
Salt tolerance: Unknown

Nutritive value

DMD: 50-72%
ME: 7.3-10.7 MJ
Crude protein: 9.0-30%

Environmental benefits

Weed control and ability to spread: Has a competitive advantage and grows well on loose, sandy soils with low fertility. On these soils veldt grass sets profuse amounts of seed and will readily move into disturbed areas or invade native bushland. On farms has a low risk of invading paddocks which are regularly grazed or set-stocked.

Livestock disorders

None reported.

Management

New stands of perennial veldt grass should not be grazed in the first year until they have flowered and set seed. Perennial veldt grass persists poorly under continuous grazing as it is selectively grazed. Rotational grazing that includes a short period of heavy grazing and removal of stock once the plant height is 3-4 cm above the crown provides the best management. Aim to maintain a balance of legumes and grass in the pasture and prevent the perennial veldt grass from forming large dominant tussocks.

Productive veldt grass requires a good supply of soil N ideally provided via a companion legume. To maintain legume density ensure an adequate supply of P, K and trace elements, particularly on deep sands.

Companion species

On deep acid sands the best companion legume is serradella, however veldt grass can also be grown with subterranean clover on slightly acid soils. To stabilise sand dunes mix perennial veldt grass with a low rate of cereal rye to provide ground cover during the establishment phase.

Cultivars

‘Unarlee’ (public variety) is the original naturalised form thought to have been accidentally introduced into Australia. This variety contains a wide range of types ranging from leafy plants to those with erect stems. It typically sheds its seed. Unarlee seed is not certified.

‘Mission’ (public variety) was bred at the University of California from material selected by R.C. Rossiter of CSIRO, Perth for its ability to retain seed. The seeds are bigger, heavier and darker brown than Unarlee.

- Autumn growth of veldt grass
4.4 Phalaris (*Phalaris aquatica*)

**Features**
- drought-tolerant, tufted temperate perennial grass
- excellent winter production
- mostly dormant in summer in WA
- toxicity problems are occasionally experienced
- requires rotational grazing for persistence and optimum production.

Phalaris is a winter-active perennial grass that has erect stems and short rhizomes. It is native to the Mediterranean region and was introduced into Australia in the late 1800s. Phalaris has since become naturalised and is common along roadsides in high rainfall areas. It is widely grown in pastures in south-eastern Australia.

With correct management phalaris is a productive, palatable and persistent grass. Winter-active types provide good winter production but in most regions of WA are dormant in summer. Phalaris is one of the most drought-tolerant of the so-called ‘big-4’ temperate grasses that include cocksfoot, tall fescue and perennial ryegrass. Phalaris is not seriously affected by any plant diseases other than the occasional ergot and stem rust.

**Seasonal growth pattern**

*Prostrate, semi-winter dormant, low summer dormancy types*

*Semi-erect, winter-active, medium to high summer dormancy types*

**Description**
- tussock-forming grass up to 2 m high that spreads by short rhizomes and seed
- bluish-green foliage, leaves 15-40 cm, broad (4-15 mm), flat and hairless – young leaves are rolled in bud
- ligule 3-5 mm long and membranous, transparent to white and rounded at the tip
- leaf sheath bluish-green, hairless, round in cross-section – when cut through at the base a pink sap exudes that is useful for identifying seedlings
- inflorescence is a dense compact cylindrical panicle 50-150 mm long and 10-15 mm in diameter.
Establishment
Phalaris is small-seeded (600,000/kg) and should be sown at a depth of 5-10 mm. If sown alone the suggested sowing rate is 3-5 kg/ha, which gives 140-230 viable seeds/m².

Phalaris is sown in autumn and can be established using conventional methods or direct drilling. Direct drilling is the preferred method because there is less weed competition. Germination and early seedling growth is very slow when average daily temperatures are less than 10ºC. The optimum temperature for seedling growth is 15-20ºC.

Weed control is critical to successful establishment and many phalaris sowings fail because of annual grass competition. To establish and maintain phalaris on acid soils, lime should be applied at 2.0-2.5 t/ha. Alternatively, a more acid-tolerant grass could be sown.

Livestock disorders
Phalaris is a valuable pasture species but occasionally animals suffer toxicity problems. Phalaris contains several dimethylated tryptamine alkaloids and these alkaloids are thought to interfere with the heart, spinal cord and brain. The alkaloid content varies with the pasture’s stage of growth. Young, vigorously growing phalaris is more likely to be toxic. Risk is also higher following a break in the weather. Animals are most at risk when moved onto fresh phalaris after grazing poor quality, low protein feed such

Soil–climate adaptation
Rainfall (est.): >500 mm (south coast >400 mm)
Season length: >6 months
Drought tolerance: High
Frost tolerance: High
Soil type: Deep medium- to fine-textured, will grow on coarse-textured if clay within 30 cm of surface
Soil fertility requirements: High
Soil pH: >4.7
Aluminium tolerance: Moderate
Waterlogging tolerance: High
Salt tolerance: Slight

Nutritive value
DMD: 53-82%
ME: 7.4-11.8 MJ
Crude protein: 5.7-26.8%

Environmental benefits
Phalaris has limited to modest groundwater recharge control in areas with <600 mm.
as dry autumn residues. High soil nitrogen, low light intensities within the sward and high temperatures are likely to increase the incidence of toxicity. Sheep are more commonly affected by toxicity problems than cattle.

Three types of phalaris poisoning have been identified:

**Sudden death**: This is a cardiac disease and sheep can die within 2-24 hours of being put onto a phalaris pasture. Dead sheep have extended necks and rigid limbs, with some evidence of thrashing before death. Froth and blood stained discharges from the mouth and nose may be present. There is no treatment.

**Acute nervous disorder**: Signs only appear obvious if sheep are disturbed. Sheep appear nervous and walk aimlessly with a high stepping, stiff gait. In severe cases convulsions can occur.

**Phalaris staggers**: Characterised by nervous signs, which persist even when sheep are removed from toxic pastures. Staggers usually occur after long exposure to phalaris, particularly on soils deficient in cobalt. Affected sheep exhibit persistent nodding of the head and weakness in the front legs making them difficult to handle. Treating sheep with cobalt can prevent this form of poisoning but it will not cure affected sheep or prevent other forms.

**Management**

New phalaris stands sown in autumn can be crash grazed to a height of 10 cm in spring to control weeds and encourage tillering. Phalaris should then be allowed to set seed before further intense grazing or cutting. In marginal environments defer grazing until the plants are well anchored and can resist being pulled out. The length of deferral can be up to 12 months. A phalaris pasture may not reach its peak production for two to three years.

It is recommended that phalaris be rotationally grazed in a four-paddock rotation as continuous grazing will reduce its persistence – particularly when grazed by sheep. In late summer and early autumn, before the break of season, graze to about 1000-1200 kg DM/ha to remove dry residues, as this will provide room for annual clovers to establish. To prevent the plant crowns from being exposed over the hotter months do not graze below 1000 kg DM/ha, then after the autumn break, defer grazing until the pasture reaches about 1500 kg DM/ha (about six weeks). Rotationally graze pastures with six weeks rest and two weeks grazing between 500 and 1500 kg DM/ha through autumn and winter. This strategy will increase the phalaris content but could also reduce the clover content. If the annual clover content declines then continuously graze to shift the balance back in favour of the legume.

In spring, graze to keep phalaris under control (<3000 kg DM/ha, ~15 cm), but avoid repeated or continuous heavy grazing or cutting and prevent shading of flowering clovers. In marginal environments the phalaris should be allowed to flower in late spring, so that enough underground dormant buds can develop for the stand to re-establish in the following autumn. These ‘buds’, which resemble small swellings at the base of the stems, are carbohydrate stores and help the plants to survive during the hot, dry conditions over summer.
A productive phalaris pasture has a high requirement for N, P, K and S. Phalaris is more responsive to increases in soil fertility than cocksfoot and tall fescue. Regularly topdress using a phosphate-based fertiliser on soils with a low to moderate phosphorus availability or use a sulphur-based fertiliser on soils highly deficient in phosphate and sulphur to maintain a vigorous legume component. Phalaris is also sensitive to sulphur deficiency. Phalaris has a high requirement for N and this can be supplied either by a companion legume or by applications of fertiliser. Phalaris makes good quality hay or silage.

**Companion species**

Suitable companion legumes include subterranean clover, serradella, lucerne, strawberry clover and perennial lotus. Phalaris can be grown with other temperate grasses such as tall fescue, cocksfoot and ryegrass, however for successful establishment they need to be sown in separate rows. Subsequent grazing management needs to meet the requirements of all the species.

**Cultivars**

**Prostrate, semi-winter dormant, low summer dormancy types**

‘Australian’ (public variety) was the original phalaris ecotype in Australia and is the most grazing-tolerant cultivar due to its prostrate, spreading growth habit. It needs to be grazed heavily to maintain feed value. It can tolerate drought conditions in cool, high rainfall zones but is less persistent in drier marginal rainfall areas. It is resistant to insect attack. Limitations include poor seedling vigour, low winter production, high alkaloid content and poor seed retention (superseded by Australian II).

‘Uneta’ (public variety) was bred from Australian and is identical in agronomic performance but has superior seed retention (superseded by Australian II).

‘Grasslands Maru’ (public variety) has similar agronomic characteristics and performance to Australian but has better seedling vigour and lower alkaloid content.

‘Australian II’ was bred by CSIRO as a replacement for Australian, with equal or superior productivity, grazing tolerance and persistence, plus good seed retention.

‘Seedmaster’ (public variety) has identical appearance to Australian but with improved seed retention. However, compared to Australian, it is less vigorous and has inferior persistence (superseded).

**Semi-erect to erect, winter-active, medium to high summer dormancy types**

‘Sirolan’ (public variety) has an erect growth habit and does not spread laterally. It is a low alkaloid variety with high seedling vigour, high winter production and good survival through summer. Sirolan has a lower incidence of sudden death, although ‘phalaris staggers’ can still occur. It is the most persistent variety in marginal rainfall areas.

‘Sirosa’ (public variety) has a semi-erect growth habit and is similar to Sirolan but with better tolerance of acid soils, later flowering and higher alkaloid content. Sirosa is less drought-tolerant than Sirolan but superior to Australian (superseded by Holdfast).

‘Sirocco’ (public variety) has an erect growth habit. High summer dormancy but can cause poisoning if it produces sufficient summer growth (superseded by Atlas PG).

‘Holdfast’ is a semi-erect type with minimal lateral spread. Similar agronomic performance to Sirolan and Sirosa but with superior seed retention. Good seedling vigour and establishment and low in alkaloids. Persistent under harsh conditions and one of the most acid-tolerant varieties.

‘Landmaster’ is an erect type selected by CSIRO for its ability to grow on shallow, stony and moderately acid, infertile soils. Landmaster is the most tolerant cultivar of acid soils and intermediate in alkaloid content.

‘Atlas PG’ is an erect, winter-active cultivar with high summer dormancy bred by CSIRO to persist in areas that are usually marginal for phalaris. It has a low tolerance of acid soils. Atlas PG has good seedling vigour and winter production and is early flowering. It requires rotational grazing for good persistence and production.
4.5 Tall fescue (*Festuca arundinacea*)

**Features**
- palatable tufted grass tolerant of waterlogging
- ‘temperate’ and ‘Mediterranean’ types have distinct seasonal growth patterns
- supplies nutritious feed in spring and early summer
- relatively drought and heat tolerant compared to perennial ryegrass
- low seedling vigour so competition from annual grasses will cause establishment failure
- requires rest from grazing particularly with sheep.

Tall fescue is a native of Europe, temperate Asia and north-west Africa and has been introduced into temperate North and South America, New Zealand, South Africa and southern Australia because of its value as a forage.194

Tall fescue is one of the best temperate perennial grasses for supplying nutritious feed in late spring and early summer.312

Tall fescue is deep-rooted and relatively drought and heat tolerant compared to perennial ryegrass.143, 312

There are two types, each with distinct seasonal growth patterns. The spring/summer-active (temperate) types are from temperate Europe or America and the winter-active/summer-dormant (Mediterranean) types are from the Mediterranean regions of southern Europe and north Africa.143

The temperate types grow vigorously in spring, summer and autumn following rain. They grow slowly in winter but do not get frosted off as easily as cocksfoot and phalaris.143 In WA the temperate types are best suited to areas with at least seven months growing season.

The Mediterranean types are winter-active and summer-dormant and consequently have greater tolerance of summer drought.

**Description**
- perennial tussock-forming grass with erect stems typically 0.5-1.2 m in height
- dark-green foliage, leaves are large and flat 10-60 cm long and usually 3-10 mm wide, the upper surface is dull with prominent veins and the lower surface smooth and glossy (leaves are similar to annual ryegrass but not as shiny)
- ligule membranous and very short
- leaf sheaths hairless, rounded at back, may be smooth or rough, typically green but can be red to brownish-purple at base
- inflorescence is an open panicle 10-20 cm long, erect and nodding, green or purplish.
These varieties are very productive in autumn, winter and early spring with variable summer dormancy ranging from totally dormant to modest growth in response to summer rain.¹⁴³

Establishment
Tall fescue has a small seed (410,000/kg) and should be sown no deeper than 10 mm. The suggested sowing rate is 7-10 kg/ha when sown alone. A seeding rate of 7 kg/ha will result in about 200 viable seeds/m².

Tall fescue is usually sown in autumn. Low temperatures slow its germination and seedling growth more than other temperate species.⁵¹ Seedlings have poor vigour and grow slowly in the first six months compared to perennial ryegrass and phalaris.⁹⁷ To obtain good establishment do not sow tall fescue with other grasses, as it is a weak competitor.

Livestock disorders
On rare occasions stock are subject to tall fescue toxicity and fescue foot. Symptoms include heat stress, severe lameness, reduced feed intake and poor weight gains. The condition is caused by the toxin ergovaline produced by an endophyte associated with the grass. The condition is rare because the current cultivars of tall fescue are either low in or free of endophyte.¹⁴³

Management
New stands of tall fescue should not be grazed until the root system is well developed so the plants will not be pulled out of the ground. For autumn sowings this is typically in late winter to mid-spring. If weeds are a problem during establishment a registered herbicide or heavy grazing for a short period is recommended to reduce competition.¹⁴³

Ideally tall fescue pastures should be kept in the ‘active-growth’ phase to maximise tillering, growth and quality, and to enable rapid recovery following grazing and encourage companion legumes. This will normally require some form of rotational grazing between feed-on-offer limits of 800-2500 kg DM/ha.¹⁴³

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**Soil–climate adaptation**

<table>
<thead>
<tr>
<th>Rainfall (est.):</th>
<th>&gt;500 mm (south coast &gt;450 mm)¹²⁹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Season length:</td>
<td>&gt;6 months (Mediterranean types)</td>
</tr>
<tr>
<td></td>
<td>&gt;7 months (temperate types)</td>
</tr>
<tr>
<td>Drought tolerance:</td>
<td>Moderate to high¹⁹</td>
</tr>
<tr>
<td>Frost tolerance:</td>
<td>High</td>
</tr>
<tr>
<td>Soil type:</td>
<td>Wide range, best suited to medium- to fine-textured soils⁹⁷</td>
</tr>
<tr>
<td>Soil fertility requirements:</td>
<td>High</td>
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<tr>
<td>Soil pH Ca²⁺:</td>
<td>&gt;4.3¹²⁹</td>
</tr>
<tr>
<td>Aluminium tolerance:</td>
<td>Moderately sensitive⁴³⁰</td>
</tr>
<tr>
<td>Waterlogging tolerance:</td>
<td>High²²⁷</td>
</tr>
<tr>
<td>Salt tolerance:</td>
<td>Slight to moderate³³⁰</td>
</tr>
<tr>
<td>Nutritive value</td>
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</tr>
<tr>
<td>DMD:</td>
<td>60-80%¹²⁹</td>
</tr>
<tr>
<td>ME:</td>
<td>8.5-11.5 MJ¹²⁹</td>
</tr>
<tr>
<td>Crude protein:</td>
<td>7.5-25%¹²⁹</td>
</tr>
</tbody>
</table>

Environmental benefits

**Groundwater recharge control:** Preliminary data suggest temperate types will provide some degree of groundwater recharge control, however Mediterranean types may not use much more water than a deep-rooted annual pasture.

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¹⁴³
An alternative method is to allow plants to develop three leaves per tiller then graze intensively and move stock on. Mature swards of tall fescue can tolerate continuous grazing under cattle particularly in winter and spring at low to moderate stocking rates.\textsuperscript{129} For plant survival defer grazing in dry conditions, only grazing again when there is vigorous new growth.

Tall fescue responds well to applications of P, S and N. On soils with low levels of P and S, apply 20-30 kg P/ha and 20 kg S/ha annually for the first few years. Fertiliser rates can then be reduced to maintenance dressings. Tall fescue is generally grown with a companion legume, which if adequately fertilised will provide sufficient N.\textsuperscript{143} Tall fescue makes good quality hay or silage.

**Companion species**

Suitable companion legumes include subterranean clover, serradella, lucerne, strawberry clover and perennial lotus depending on the rainfall and site drainage.\textsuperscript{143} Lucerne and winter-active tall fescue should have complementary growth patterns.

**Cultivars**

**Temperate (summer-active) types**

‘Au Triumph’ (public variety) – bred in the United States for winter growth. It has good establishment, flowers early and produces large amounts of dry matter. It is endophyte-free and has been widely used in Australia since 1987.

‘Demeter’ (public variety) – a hardy cultivar with good production levels but low palatability and seedling vigour.

‘Dovey’ (public variety) – selected in south-eastern France and capable of year-round growth. Has rapid emergence and good seedling vigour. It has moderate palatability and digestibility and similar rust resistance to Au Triumph.

‘Quantum’ (public variety) – selected from Au Triumph for improved rust tolerance and softer leaves. Also available as ‘Quantum Max P’, which contains safe endophyte.

‘Grasslands Advance’\textsuperscript{14b} – bred by New Zealand AgResearch. Compared with Grasslands Roa, Advance has better seedling vigour and dry matter production and retains its feed quality. It is free of endophyte.

**Mediterranean type (winter-active, varying degrees of summer dormancy)**

‘Melik’ (public variety) – selected by CSIRO in WA with most of the field evaluation undertaken at Kojonup. It is highly summer-dormant. (Seed is no longer available.)

‘Flecha’\textsuperscript{1b} – bred in Argentina. Quite palatable with fine leaves and a semi-erect growth habit. Has rapid growth following autumn break with good winter and spring growth. Highly summer-dormant. Good persistence under sheep grazing. Rust tolerant. Also available as ‘Flecha Max P’ which contains safe endophyte.

Tall fescue has considerable potential for areas where the growing season is more than 6.5 months.
Perennial pastures for Western Australia

Temperate perennial grasses

‘Fraydo‘ – selected by Agriculture Victoria from Melik. Has an erect habit, medium leaf width and is early maturing. Highly summer-dormant.

‘Prosper‘ – has fine leaves and semi-erect growth habit which is intermediate between Fraydo and Flecha. Can be used on irrigated pastures.

‘Resolute‘ – selected from Melik. Highly summer-dormant. Also available as ‘Resolute Max P‘ which contains safe endophyte.

The relative growth in winter of a temperate, summer-active tall fescue variety (left) and a winter-active variety (right)

A wide row spacing should be used in marginal environments, as demonstrated by the strong edge effect in this plot