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Perennial Grass and Herb Options for the Upper South-East of South Australia

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About the Authors

Dr Sean Miller has been involved in agricultural research, development and extension for the past 19 years. Over this period he has applied his skills in pasture management and ruminant nutrition to promote agricultural development in both Australia and overseas. In association with SARDI and the CRC for Plant-based Management of Dryland Salinity, his recent work has focussed upon developing and testing new pasture species for temperate and Mediterranean perennial pastures, and areas affected by dryland salinity.

Andrew Craig has had over 28 years experience evaluating and developing temperate pasture species and has led Australian efforts to promote balansa clover. During his career he has also been involved in the development of a number of other temperate pasture legume cultivars. Over the last 10 years his interests have widened to include the identification of salt-tolerant fodder plants while his involvement with the CRC for Plant-based Management of Dryland Salinity has also provided the opportunity to evaluate a number of new, exciting perennial fodder species.

Summary

Field studies in the 460-500 mm rainfall region of the Upper South-East of South Australia have demonstrated the robustness of several commercial perennial grass and herb cultivars and their suitability for inclusion in perennial pasture mixes. Deep-rooted perennial fodder plants play a vital role in combating dryland salinity by increasing water use and by reducing groundwater recharge. They also possess the capacity to produce valuable 'out of season' feed for livestock.

Chicory and plantain are relatively new introductions to the region and their exceptional performance suggests that producers could make more use of these species.

Phalaris was one of the most productive and consistent performers across all field sites and provides a valuable benchmark for the region. It was clearly the best performer where winter waterlogging was evident. In contrast, Currie and Porto cocksfoot only performed well on free-draining, sandy soils where clay was close to the soil surface. Their use should be restricted to these situations.

Tall fescues performed strongly in the second and third years after sowing, with the winter-active cultivars being most persistent.

Mission veldt grass grew extremely well except on winter waterlogged soils prone to inundation. Mission's nutritive value proved equal to the best of the other grasses evaluated, contrary to popular belief. Dundas tall wheatgrass appeared to have similar soil type preferences to cocksfoot, however its nutritive value was notably lower than other species.

The perennial bromes and perennial ryegrasses lacked persistence and do not appear to be viable long-term options for the region. The native and sub-tropical grasses yielded poorly.

Scope of the studies

In partnership with the Cooperative Research Centre for Plant-based Management of Dryland Salinity and the Grains Research and Development Corporation, SARDI has concluded a series of research trials in the Upper South-East region to evaluate perennial pasture options with the capacity to improve farm productivity and reduce groundwater recharge.

Commercial and experimental perennial grasses and herbs were evaluated in replicated trials at four sites. Only data from selected commercially available cultivars that are readily accessible by farmers have been presented in this publication. Measurements taken at the sites included seasonal productivity, per cent groundcover (as an indicator of persistence) and nutritive value.

The purpose of this bulletin is to provide producers and agronomists with information on the relative growth, persistence and adaptation of a range of commercially available perennial grasses and herbs when grown in the Upper South-East of SA (Tables 1 and 2). The information may be used to make comparisons between species and cultivars when considering options for sowing new pastures in this region. Such decisions must be considered in the context of the management regime that was imposed on these field trials.

Table 1. Grasses sown in Upper South-East trials

Species	**Cultivars**	**Sites**			
		Keith	**Willalooka South**	**Willalooka North**	**South Taunta**
Brome *(Bromus unioloides)*	Atom		✓	✓	✓
Brome *(Bromus stamineus)*	Gala	✓	✓	✓	✓
Brome *(Bromus valdivianus)*	Bareno			✓	✓
Cocksfoot *(Dactylis glomerata)*	Currie	✓	✓	✓	✓
Cocksfoot	Porto	✓		✓	✓
Kangaroo grass *(Themeda australis)*	Betts	✓	✓		
Kikuyu *(Pennisetum clandestinum)*	Whittet	✓	✓		
Panic *(Panicum maximum)*	Gatton	✓	✓		
Perennial ryegrass *(Lolium perenne)*	Avalon	✓			
Perennial ryegrass	Camel		✓		
Phalaris *(Phalaris aquatica)*	Atlas PG	✓	✓	✓	✓
Phalaris	Australian	✓			
Phalaris	Holdfast	✓		✓	✓
Phalaris	Sirolan		✓	✓	✓
Phalaris	Sirosa			✓	✓
Rhodes grass (*Chloris gayaya*)	Katambora	✓	✓		
Setaria (*Setaria sphacelata*)	Narok	✓	✓		
Tall fescue (*Festuca arundinacea*)	AU Triumph	✓	✓	✓	✓
Tall fescue	Flecha			✓	✓
Tall fescue	Fraydo	✓		✓	✓
Tall fescue	Prosper		✓	✓	✓
Tall fescue	Quantum		✓	✓	✓
Tall fescue	Resolute	✓	✓	✓	✓
Tall wheatgrass *(Thinopyrum ponticum)*	Dundas	✓	✓	✓	✓
Veldt grass *(Ehrharta calycina)*	Mission	✓	✓	✓	✓
Wallaby grass *(Austrodanthonia richardsonii)*	Taranna	✓	✓		
Weeping grass *(Microlaena stipoides)*	Wakefield	✓	✓		

Table 2. Herbs sown in Upper South-East trials

Species	Cultivar	Keith	Willalooka South	Willalooka North	South Taunta
Chicory *(Cichorium intybus)*	Chico			✓	✓
Chicory	Grouse	✓	✓	✓	✓
Chicory	Le Lacerta			✓	✓
Chicory	Puna	✓	✓	✓	✓
Plantain *(Plantago lanceolata)*	Tonic	✓	✓	✓	✓

Role of perennials

Deep-rooted perennial pasture plants play an important role in combating dryland salinity by increasing water use and by reducing groundwater recharge. It is widely recognised that to prevent the further spread of salinity, perennial-based land use systems will need to be adopted on a large proportion of the existing landscape. However, the current use of these systems is relatively low due to a lack of sound information on the productivity of the available options.

A prerequisite for change is to identify new perennial plant options that can be confidently introduced as components of mainstream pastures. Historically, this has proven challenging as many of the areas targeted for increased use of perennial species are prone to winter-waterlogging and long, dry summers. Such conditions have proven to be serious impediments for the use of these species.

An additional benefit provided by many perennial fodder plants is their capacity to produce valuable 'out of season' feed for grazing livestock. The ability of these plants to grow rapidly in response to rainfall events, either early in the season (early autumn feed), or in response to out-of-season rainfall (summer feed), ensures an additional source of nutrients at critical times during the year. Annual pasture species do not possess this capacity.

Importance of seasonal production

Many perennial pasture species are represented by a range of cultivars, each of which exhibits distinct seasonal growth patterns. This is particularly evident for chicory, cocksfoot, and tall fescue cultivars that are sold in Australia. Differences in seasonal growth are typically derived from the parent material used to breed and select the various cultivars. Examples of a range of growth patterns observed between some commonly used cultivars are shown in Figures 1 and 2..

When sowing a new perennial pasture, there is often merit in using a mixture of species and cultivars with complementary growth patterns. The benefits of using such mixtures lie in producing more feed over a greater proportion of the growing season.

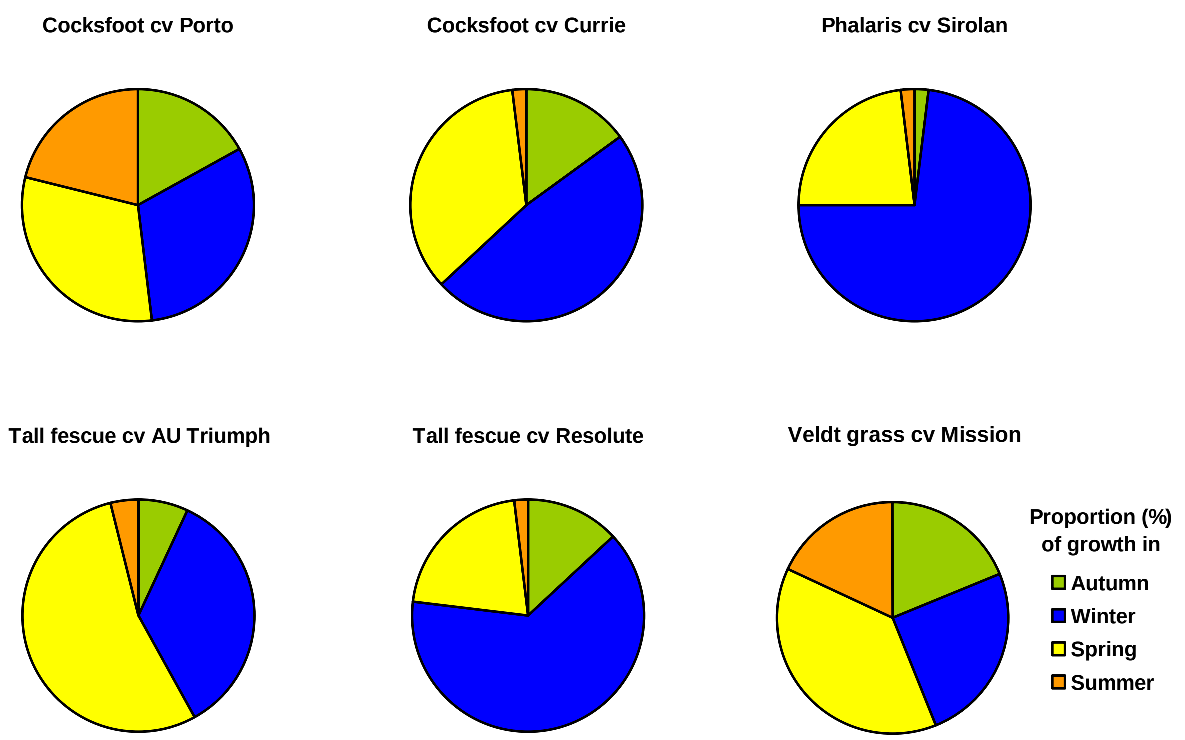

Figure 1. Relative seasonal herbage production of perennial grasses in the Upper South-East of South Australia

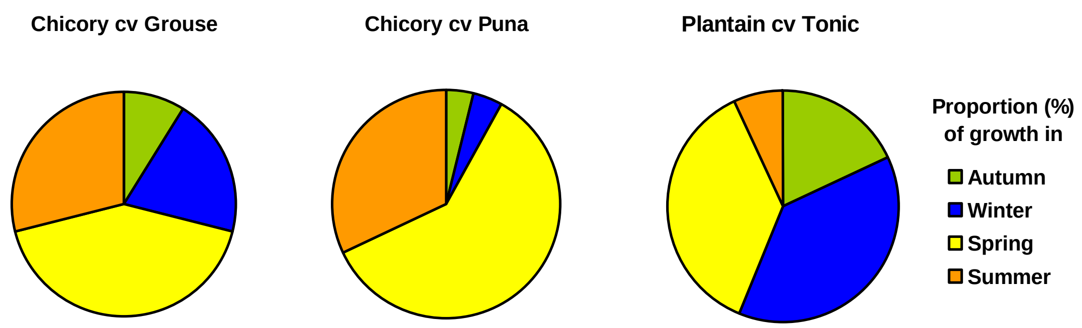

Figure 2. Seasonal production of perennial herbs at Keith and Willalooka South

Location of field sites

Four field sites were established between July 2002 and June 2004 - one at Keith (sown in July 2002), two at Willalooka (Willalooka South, sown in August 2003; and Willalooka North, sown in June 2004), and one at South Taunta (sown in June 2004). The sites were selected as representative of the surrounding agricultural land.

The field sites received average annual rainfall of 414 mm at Keith, 450 mm at Willalooka North and South, and 400 mm at South Taunta over the course of the study. These are below the long-term averages for these districts.

Soil types

The predominant soil types at both Keith and Willalooka South were acidic bleached sands overlying a clay layer at 30-45 cm deep. Both sites were free draining and not subjected to waterlogging during winter.

Soil profile at the Keith and Willalooka South sites

Soil profile at the Willalooka North site

The soil at Willalooka North was an acidic red loam that was prone to extended periods of waterlogging and inundation during winter.

Soil profile at the South Taunta site

The soil at South Taunta was the least uniform of the trial locations. The site was free draining and did not experience winter waterlogging. The topsoil consisted of an alkaline sand overlying clay, however the depth to clay varied from 30 to 150 cm across the site. This resulted in large variations in performance of some cultivars and hence the results for this site have been presented on the basis of the two predominant soil types.

Characteristics of soils at the four sites are summarised in Table 3.

Table 3. Characteristics of the four soil sites

Location	**Year sown**	**Soil description**	**pH$_w$**	**Depth to clay (cm)**	**Drainage**
Keith	2002	Shallow sand over clay	5.9	30-45	Free draining
Willalooka South	2003	Shallow sand over clay	5.8	30-45	Free draining
Willalooka North	2004	Red loam	5.5	30	Winter waterlogged
South Taunta	2004	Sand over clay	8.5	30-150	Free draining

Management of field sites

Field sites were established in winter with seed sown at recommended commercial rates. Sites were maintained for up to three years, and herbage yield and persistence, as measured by change in percentage groundcover, of individual cultivars were recorded. Herbage yield was assessed at the end of summer, autumn and winter, and on two occasions during spring. The sites were either grazed by sheep or mown to a height of 2 cm above ground level after each yield assessment.

Sites were topdressed with phosphorus, potassium and trace elements annually, and weeds were controlled with herbicides when necessary.

Trial entries were sown without companion legumes to make for easier measurement. As no legumes were sown, fertiliser nitrogen in the form of urea was applied at 30 kg/ha after each herbage assessment.

Species performance

Temperate perennial grasses

The performance of the pasture species under test was assessed primarily by determining seasonal dry matter production and total dry matter yield over the trial period and is shown in Tables 4-6. Long-term performance is particularly important for perennial species as they can often be slower to establish than annuals. Differences in establishment rates (early growth) between perennial species are often quite significant and should be noted. Readers should also take note of the effect of different soil types on species performance as these can vary considerably. In some situations the amount of ground covered by a particular species was also determined to provide another measure of species persistence.

Table 4. Seasonal and total herbage yields (kg/ha) of perennial grasses and herbs grown at Keith between 2002 and 2004

Species	**Cultivar**	**Winter-Spring 2002**	**Summer 2002**	**Autumn 2003**	**Winter 2003**	**Spring 2003**	**Summer 2003**	**Autumn 2004**	**Winter 2004**	**Total kg/ha**
Brome	Gala	2,456	0	288	2,655	2,257	313	564	1,094	**9,627**
Chicory	Grouse	3,219	1,101	237	991	2,320	2,696	904	1,852	**13,320**
Cocksfoot	Currie	1,451	0	163	1,776	1,803	319	1,803	1,613	**8,928**
Cocksfoot	Porto	1,405	856	346	1,777	1,997	1,541	1,742	1,424	**11,088**
Perennial ryegrass	Avalon	1,516	0	324	2,153	1,950	321	431	1,048	**7,743**
Phalaris	Atlas PG	1,877	0	305	3,103	1,567	65	2,020	1,882	**10,819**
Phalaris	Australian	1,038	86	349	2,254	2,090	73	1,306	1,592	**8,788**
Phalaris	Holdfast	1,439	0	248	3,042	2,008	51	1,722	1,649	**10,159**
Plantain	Tonic	1,441	234	278	2,619	3,398	643	2,051	2,343	**13,007**
Tall fescue	AU Triumph	1,134	356	382	2,463	2,110	351	822	1,547	**9,165**
Tall fescue	Fraydo	783	0	290	2,960	1,138	61	1,470	1,615	**8,317**
Tall fescue	Resolute	868	0	319	2,977	1,310	53	1,852	1,463	**8,842**
Tall wheatgrass	Dundas	1,638	635	376	1,894	2,103	791	231	613	**8,281**
Veldt grass	Mission	2,668	1,392	363	1,728	1,583	703	2,301	786	**11,524**

Table 5. Seasonal and total herbage yields (kg/ha) of perennial grasses grown at Willalooka South between 2003 and 2005

Species	**Cultivar**	**Spring 2003**	**Summer 2003**	**Autumn 2004**	**Winter 2004**	**Spring 2004**	**Summer 2004***	**Autumn 2005***	**Winter 2005**	**Spring 2005**	**Total kg/ha**
Brome	Atom	3,523	720	748	2,494	2,152	0	0	809	1,767	**12,213**
Brome	Gala	349	325	471	1,706	1,759	0	0	760	955	**6,325**
Cocksfoot	Currie	127	156	464	1,507	1,464	0	0	1,098	2,527	**7,343**
Perennial ryegrass	Camel	148	238	291	1,519	1,323	0	0	572	1,376	**5,467**
Phalaris	Atlas PG	886	85	57	1,868	939	0	0	2,878	3,090	**9,803**
Phalaris	Sirolan	538	161	120	2,556	975	0	0	3,466	3,166	**10,982**
Tall fescue	AU Triumph	325	241	398	1,383	1254	0	0	689	1,639	**5,929**
Tall fescue	Prosper	44	84	190	1,559	1,145	0	0	970	1,736	**5,728**
Tall fescue	Quantum	425	269	486	1,341	1,302	0	0	787	1,507	**6,117**
Tall fescue	Resolute	117	106	91	1,842	741	0	0	1,768	2,488	**7,153**
Tall wheatgrass	Dundas	179	257	398	1,250	2,568	0	0	868	2,317	**7,837**
Veldt grass	Mission	467	1,601	1,291	1,411	2,691	0	0	1,187	2,218	**10,866**

* failed to produce any measurable growth over this period, due to the lack of rainfall

Table 6. Combined winter and spring herbage yields of perennial grasses grown on two different soil types at South Taunta and Willalooka North during 2005

		Herbage yield (kg/ha)		
		South Taunta		Willalooka North
Species	**Cultivar**	**Sand over clay at depth**	**Shallow sand over clay**	**Red loam**
Brome	Atom	27	916	903
Brome	Gala	0	0	605
Brome	Bareno	0	0	13
Cocksfoot	Currie	17	1,221	1,097
Cocksfoot	Porto	71	1,051	701
Phalaris	Atlas PG	1,593	2,060	2,198
Phalaris	Holdfast	522	2,005	3,071
Phalaris	Sirolan	1,784	3,582	4,255
Phalaris	Sirosa	730	2,587	3,104
Tall fescue	AU Triumph	1,422	1,722	1,372
Tall fescue	Flecha	1,858	1,897	2,276
Tall fescue	Fraydo	1,543	2,374	2,064
Tall fescue	Prosper	1,755	2,488	ns
Tall fescue	Quantum	981	1,531	ns
Tall fescue	Resolute	2,210	2,473	1,896
Tall wheatgrass	Dundas	839	2,252	881
Veldt grass	Mission	2,908	2,346	2,066

ns: not sown

Phalaris (cultivars: Atlas PG, Australian, Holdfast, Sirolan & Sirosa)

Phalaris cultivars were among the most persistent and productive temperate grasses at all sites and are the benchmark against which all other species can be compared (Tables 4, 5 and 6). Sirolan was one of the most productive cultivars. Phalaris cultivars exhibited high winter activity in the year after establishment, with the most productive cultivars achieving growth rates between 30 and 40 kg/ha/day.

Sirolan and Atlas PG performed better on the more hostile deep sands at South Taunta than Sirosa and Holdfast (Table 6). Phalaris was very productive on the red loam soil at Willalooka North and appeared particularly well adapted to this winter-waterlogged environment.

NSW field studies (Crosbie 2006) show that Atlas PG is a more persistent option than Sirolan. However, our data have been unable to identify any differences between these two cultivars.

Phalaris has the potential to cause health problems in both sheep and cattle, although the risks have been minimised in newer cultivars. Further information on the potential health risks posed to livestock, and general information on establishing and managing phalaris pastures can be found in NSW Agriculture Agfact 2.5.1.

Tall fescue (cultivars: AU Triumph, Flecha, Fraydo, Prosper, Quantum & Resolute)

In recent years, tall fescue has gained a reputation as a persistent option for perennial pastures in the medium rainfall zones of southern Australia. Tall fescue cultivars can be separated into two broad groups based on their seasonal growth. The temperate or continental varieties are active in spring, summer and autumn with slower growth in winter. The Mediterranean varieties grow actively from late autumn to early spring but are dormant in summer. Of the tall fescue cultivars evaluated, Prosper, Flecha and Fraydo are winter-active while AU Triumph and Quantum are summer-active. Resolute is also winter-active, however, it has been reported to possess the ability to respond to summer rainfall.

Traditional tall fescue varieties such as Demeter have been grown in areas that experience either mild summers or receive significant summer rainfall. The introduction of new cultivars with summer dormancy and increased winter activity has extended the area where tall fescue has a role. Our trials have confirmed the value of tall fescues for improving pasture productivity in the Upper South-East.

All tall fescue varieties have relatively poor seedling vigour and hence slow growth in the establishment year. In these studies they produced lower cumulative yields than phalaris. However, herbage production in the second year generally matched that of the best phalaris cultivars. Although not as productive as veldt grass, Resolute, Prosper, Fraydo and Flecha appear well suited to the deeper sandy soils at South Taunta (Table 6), and may supplement the winter productivity of veldt grass pastures on these soils.

Resolute tall fescue, Atlas PG and Holdfast phalaris were the three most persistent cultivars in these studies. The summer-active cultivars AU Triumph and Quantum lacked long-term persistence compared with the more winter-active Resolute (Figures 3a and 3b), most likely resulting from a lack of summer rainfall and high temperatures. However both cultivars ‘greened up’ quickly in response to summer rain, suggesting that they may perform better in cooler, southern environments.

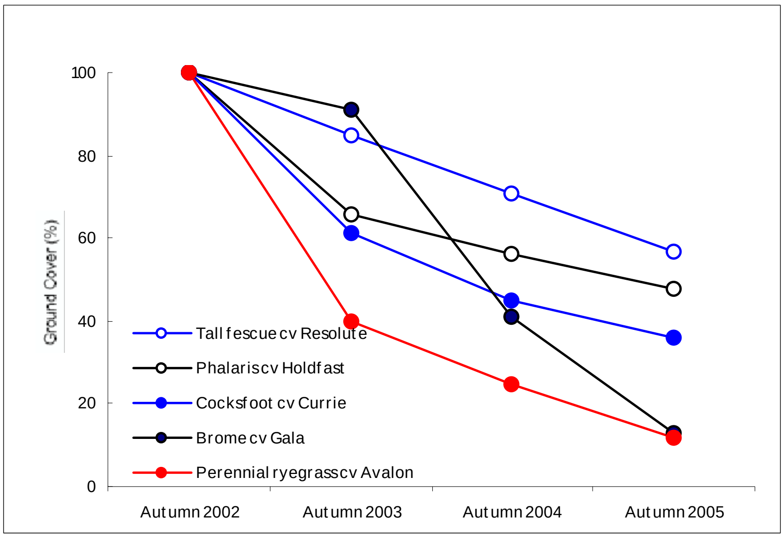

Figure 3a. Percentage groundcover (as an indicator of persistence) of winter-active perennial grasses at Keith from 2002 to 2005

Cocksfoot (cultivars: Currie & Porto)

Currie cocksfoot has long had a reputation for good drought tolerance, poor tolerance of waterlogging, and for poorer feed quality than many other temperate perennial grasses. Our studies confirmed the superior drought tolerance of Currie, relative to the more summer-active cultivar Porto (Figures 3a and 3b). At Keith, summer rainfall during the evaluation period was insufficient for Porto to express its growth potential and this is likely to have compromised its persistence.

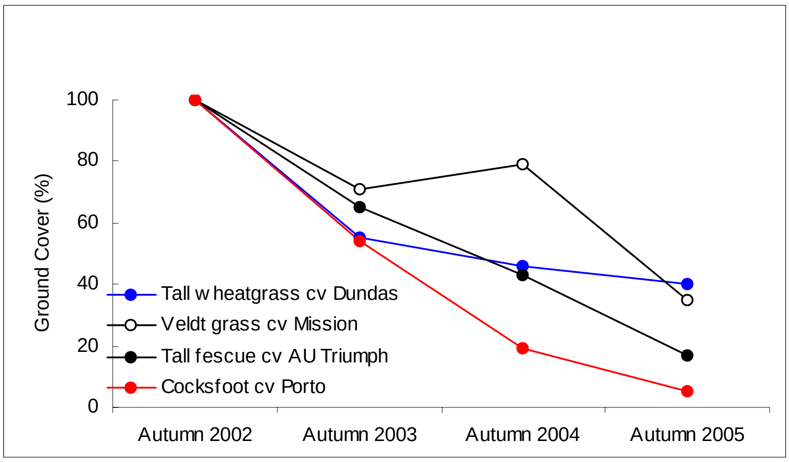

Figure 3b. Percentage groundcover (as an indicator of persistence) of summer-active perennial grasses at Keith from 2002 to 2005

Cocksfoot (left) and phalaris (right) regrowth during summer

Both cocksfoot cultivars demonstrated poor tolerance to the winter-waterlogged conditions at Willalooka North and on the deep sands at South Taunta, but appeared much better suited to situations where the clay is close to the soil surface.

Contrary to traditional belief, the feed quality of Currie cocksfoot was among the highest of all grasses measured (Figures 4 and 5), having high levels of both crude protein and metabolisable energy (digestibility) in mid-spring.

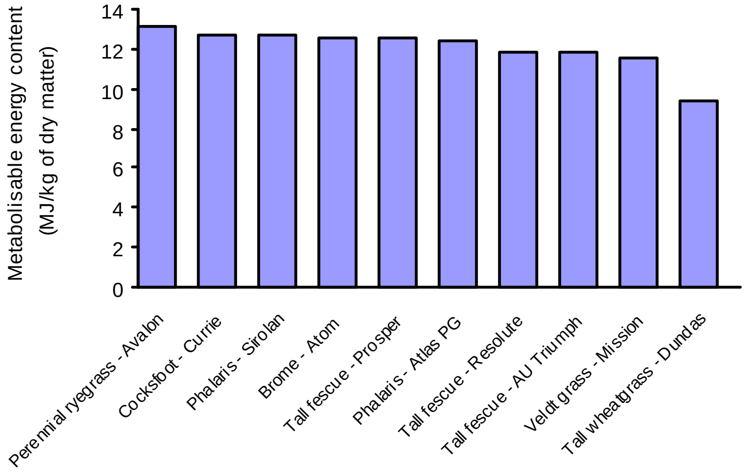

Figure 4. Metabolisable energy content of selected perennial grasses in mid-spring 2005

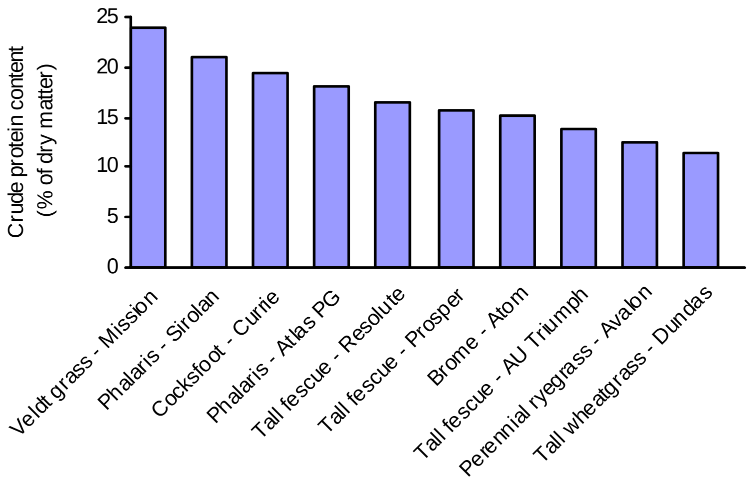

Figure 5. Crude protein content of selected perennial grasses in mid-spring 2005

Veldt grass (cultivar: Mission)

Mission veldt grass is widely distributed throughout the region and our studies suggest that it is under-valued as a pasture species. Mission ranked among the top performing entries at all free draining sites. Its ability to contribute some summer growth complemented its high spring yield. However, its yield over winter is substantially lower than phalaris.

As a result of an extended period of low rainfall during the summer of 2004-05, plant numbers of Mission in the trial plots at Keith declined rapidly. However, it still remained one of the most persistent grasses (Figure 3b). Mission remains a species of choice for the deep sandy soils of the region.

Nutritive value analysis indicates that Mission is a high value species in spring and few perennial grasses are able to match its crude protein content. Its metabolisable energy content was also comparable with the other species tested (Figures 4 and 5).

Tall wheatgrass (cultivar: Dundas)

Tall wheatgrass is used widely in the saline areas to the west of Keith. Dundas was selected from cv. Tyrrell as a leafier, more nutritious alternative (Anon 2000). While Dundas is capable of summer growth, the bulk of its production occurred during the late winter-spring period. Its cumulative herbage yields at Keith and Willalooka South were comparable with those produced by Resolute tall fescue and Currie cocksfoot, but fell short of the yields produced by phalaris and Mission veldt grass.

Despite displaying good persistence throughout the trial period, Dundas was consistently outperformed by other species. In addition, the spring crude protein and energy content of Dundas was lower than that of all other grasses. This appears to suggest that this cultivar is best suited to environments where its ability to tolerate moderate salt and waterlogging (Dooley 2003) can be exploited.

Brome grass (cultivars: Atom, Bareno & Gala)

Perennial bromes have traditionally been associated with high rainfall regions on well drained soils. These studies indicated that the bromes are unsuited to either winter-waterlogged soils or deep infertile sands.

Gala grazing brome was very productive during the first two years at Keith, however dry summers in 2003 and 2004 reduced groundcover from 100% to approximately 10% (Figure 3a), resulting in reduced herbage yield. At South Taunta, both Gala and Bareno failed to survive beyond the year of establishment.

Atom established rapidly in the year of sowing and at Willalooka South its first year production far exceeded all other species. Atom's ability to survive summer drought was tested during 2004, and although the plots remained productive, this occurred mainly from regeneration from seed. Atom matures relatively early and seeds prolifically.

Perennial ryegrass (cultivars: Avalon & Camel)

Perennial ryegrass has not generally been recommended as a component of permanent pastures for the Upper South-East because it requires higher rainfall to ensure satisfactory levels of persistence. This was confirmed in our studies as neither Avalon nor Camel persisted sufficiently beyond the second summer to maintain a viable pasture. Despite being bred for increased drought tolerance, Camel failed to demonstrate satisfactory persistence in our trials.

Native and sub-tropical perennial grasses

Native species: Betts kangaroo grass, Taranna wallaby grass & Wakefield weeping grass

The native grasses performed poorly at all sites. Establishment proved more difficult for these than for the introduced grasses, although Wakefield and Taranna were established with some success. However, neither cultivar produced comparable herbage yields to any of the traditional temperate grass cultivars tested. Given the high cost of seed, difficulties in establishment and relatively poor seedling vigour there would appear to be little scope for these cultivars in the high production pasture systems of the Upper South-East.

Sub-tropical species: Gatton panic, Katambora Rhodes grass, Narok setaria & Whittet kikuyu

Most of the sub-tropical grasses (Katambora, Gatton and Narok) proved difficult to establish and as a consequence yielded poorly. While Whittet kikuyu established successfully, the lack of summer rainfall restricted its productivity over the warmer months – the period of its maximum growth potential. During the cooler period of the year its productivity was vastly inferior to most of the temperate pasture grasses. These species appear unsuited to this region, being better adapted to areas receiving significant summer rainfall.

Perennial herbs

Chicory (cultivars: Chico, Grouse, Le Lacerta & Puna); Plantain (cultivar: Tonic)

Chicory and plantain are relatively new introductions to the Upper South-East, traditionally being associated with higher rainfall environments. Grouse chicory and Tonic plantain were excellent performers; each produced more than the grasses evaluated at Keith (Table 4). However after three years, plant numbers of both species had declined substantially (Figure 6), and it remains unclear what level of groundcover is required to maintain a productive pasture. In contrast, a number of the better-adapted grasses retained high levels of groundcover.

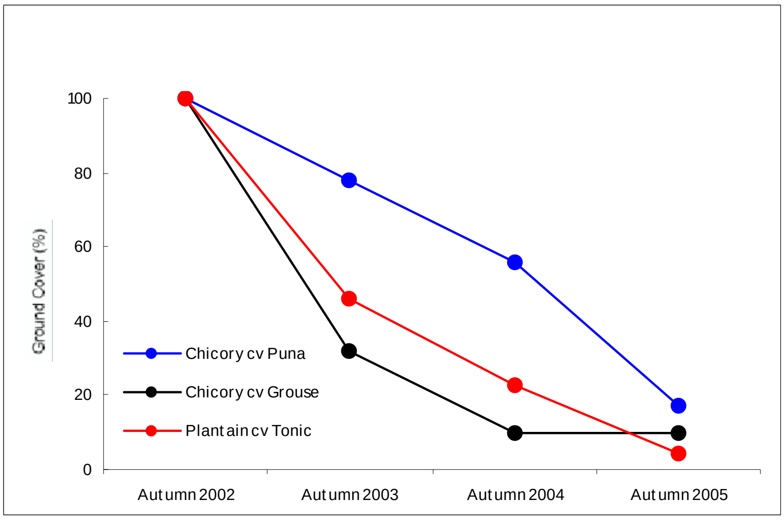

Figure 6. Percentage groundcover (as an indicator of persistence) of perennial herbs at Keith from 2002 to 2005

Chicory establishes readily in the year of sowing

The growth patterns of chicory and plantain appear complementary. Plantain is more winter-active than all the chicories with its peak production occurring during winter and spring. In contrast, chicories responded to increasing temperatures and produced most of their growth in spring and summer (Figure 2).

Le Lacerta, Chico and Grouse chicory have similar erect growth habits, while Puna is a prostrate cultivar. Puna produced only half the dry matter of each of the other cultivars at South Taunta. All cultivars displayed an impressive ability to grow on deeper sands (up to 1.5 m to the clay sub-layer) as summarised in Table 7. This ability makes chicory a viable alternative to lucerne. This can, in part, be attributed to chicory's deep taproot which enables it to extract moisture and nutrients at depth. It should be remembered, however, that chicory and plantain are not legumes and will require periodic nitrogen applications to ensure that they reach their full potential.

Table 7. Total herbage yields of chicory cultivars grown on different soil types at South Taunta between May 2005 and January 2006

	Herbage yield (kg/ha)	
Cultivar	**Sand over clay at depth**	**Shallow sand over clay**
Chico	11,573	6,744
Grouse	12,827	6,068
Le Lacerta	12,191	7,279
Puna	5,654	3,572

Caution must be exercised when using herbicides to manage chicory and plantain. Few herbicides are registered for use with either species, and advice should be sought from appropriate agencies before application. For example, we observed very different levels of trifluralin tolerance (see photo below) between the two species. While chicory appeared to tolerate trifluralin, plantain by comparison was highly susceptible with large seedling losses.

The effect of trifluralin on Tonic plantain, Sirolan phalaris and Grouse chicory

Further reading

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