Use and improvement of tall fescue and phalaris for the North-West Slopes

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Abstract. The summer rainfall of the North-West Slopes combined with high summer temperatures provides a challenging environment for introduced temperate perennial grasses. Trials comparing the persistence of introduced grasses have indicated phalaris and tall fescue to be the most promising species for the slopes regions of NSW. This paper describes the cultivars and use of tall fescue and phalaris as well as the current plant improvement programs for these species with particular relevance to the North-West Slopes.

Introduction

In the pasture zone of northern NSW, there are 2 distinct bioregions: the Northern Tablelands and North-West Slopes covering approximately 6.5 million hectares. This zone is a sub-humid summer rainfall area (Tweedie and Robinson 1963), with approximately 60% of annual rain occurring from October to March. Rainfall is related to altitude, being highest on the peaks of the Tablelands (1250 mm) and decreasing as elevation falls towards the western edge of the Slopes (400 mm). Much of this rain falls as high intensity thunderstorms, leading to a high risk of surface runoff. Pan evaporation rates are high over summer (8-10 mm/day) and monthly totals exceed rainfall in nearly all months reducing the effectiveness of the rain. Frosts occur from April to October on the Tablelands with a reduction in both intensity and length of frost period at lower elevation on the Slopes. Low temperature (particularly on the Tablelands) may restrict pasture growth over winter and a combination of high temperature and lack of soil moisture can restrict pasture growth and persistence over summer.

Summer-growing native perennial grasses dominate the natural pastures of the region limiting animal production due to the low supply of green feed in the winter to early spring period. Sown temperate perennial grasses and legumes can alleviate this limitation and allow more intensive production with the capacity to fatten livestock (Lodge *et al.* 1991; Dicker *et al.* 1998). Perennial grasses also have an important role for sustainability in this region because of the ability of their deep-roots to dry the soil profile, their large crowns, high levels of ground cover, and less degradable organic matter than lucerne (*Medicago sativa*).

Introduced temperate perennial grasses are well suited climatically to the Northern Tablelands (Ayres *et al.* 2000), but their survival is much lower in the hotter and drier environment of the North-West Slopes (Lodge *et al.* 1991; Lodge and Orchard 2000). Archer (1989) concluded that phalaris (*Phalaris aquatica*) was the most persistent and suitable of 4 introduced temperate grasses for long-term pastures on the North-West Slopes, however, tall fescue (*Festuca arundinacea*) and cocksfoot (*dactylis glomerata*) retained a reasonable presence at the completion of the study (4 years). Lodge (2002) showed that Sirosa phalaris persisted better than Demeter tall fescue and Kangaroo Valley perennial ryegrass (*Lolium perenne*) at a low altitude site. As is also commonly observed by farmers, all sown species failed in <6 years with higher grazing pressure and drought, whereas native perennials survived. Similar results were obtained in a grazed experiment (Fig. 1) at Tamworth (430 m

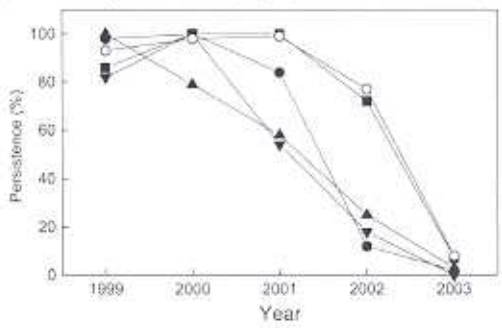

Figure. 1. Persistence (as a percentage of maximum basal frequency) of phalaris (5 cvs., ■), cocksfoot (2 cvs., ▼), perennial ryegrass (2 cvs.,▲), and Triumph (●) and Fraydo (○) tall fescue in grazed swards at Tamworth (Boschma and Culvenor, unpublished).

altitude), except that the Mediterranean tall fescue cv. Fraydo persisted as well as phalaris. Phalaris and tall fescue therefore appear to be the most promising sown temperate grass species for the Slopes regions of northern NSW. This paper examines recent developments in tall fescue and phalaris with relevance to the North-West Slopes.

Tall fescue

Tall fescue is grown in south-east Queensland, through the Tablelands and upper Slopes of NSW and Victoria and in suitable areas of Tasmania, South Australia, and Western Australia. In 1998, the estimated area sown to tall fescue in NSW was approximately 0.94 million hectares, most abundantly on the Northern Tablelands where growth potential is maximised by summer rainfall and mild temperatures (Hill and Donald 1998).

Tall fescue is a deep-rooted grass adapted to a wide range of soil types including those with moderate levels of acidity, salinity, and fertility. It is more tolerant of waterlogging than cocksfoot and more tolerant of soil acidity than phalaris (Easton *et al.* 1994). Research on the Northern Tablelands has demonstrated the longer growing season and higher grazing value of tall fescue/white clover pastures compared to phalaris/white clover pastures (Ayres *et al.* 2000). Despite the strengths of tall fescue, the existing cultivars have weaknesses including low winter activity, low nutritive value of mature leaf and stem, poor seedling vigour and poor persistence in marginal rainfall environments.

Tall fescue cultivars

Two types of tall fescue are grown in Australia: those that originate from temperate Europe or America (spring/summer active varieties) and those of Mediterranean origin (winter active/summer dormant).

The temperate varieties grow vigorously in spring, summer, and early autumn, but have slow winter growth. These varieties are the most commonly used in NSW, providing good year-round production of quality feed, not frosting off in winter as readily as cocksfoot and phalaris. Temperate varieties include Au Triumph, Demeter, Dovey, Jesup, Quantum, Torpedo and Vulcan II. These are suited to temperate areas of NSW with an annual average summer dominant rainfall >650 mm. The temperate varieties are particularly well suited to higher altitude (>700 m) areas of NSW. At lower altitudes where irrigation is used these varieties will also grow well, but with reduced persistence.

Mediterranean varieties are winter active, summer dormant and tolerate summer drought better than the temperate varieties. They have a more pronounced winter and early spring growth pattern, similar to phalaris. The level of summer dormancy varies with cultivars ranging from totally summer dormant to some production in response to summer rain. Until recently, these Mediterranean types were not commonly used in Australia, however, today there are a number of new Mediterranean varieties available (e.g. Flecha, Fraydo, Prosper and Resolute). These varieties are better suited to dry summer Mediterranean environments, with an annual average rainfall >450-500 mm with winter incidence.

The use of Mediterranean tall fescue varieties has extended the zone of adaptation of tall fescue into summer dry areas of southern NSW and Victoria. The advantage of the Mediterranean material is increased winter growth and good persistence under moisture stress. However, in regions with some summer rainfall the Mediterranean cultivar Melik had lower annual yield than that of Demeter (Clarke *et al.* 1993). The challenge for the North-West Slopes is to identify material with the enhanced winter growth and persistence characteristics of the Mediterranean types, but with the ability to grow over summer and give high annual yield to increase animal production and water use.

Developments with tall fescue novel endophyte

Tall fescue endophyte is a fungus (*Neotyphodium coenophalium*) that lives inside the tall fescue plant. The endophyte and the plant have a symbiotic relationship where the host supplies the endophyte with nutrients and a mode of spread by the host plant's seed. The plant benefits through increased tolerance to insect attack, increased tolerance to moisture stress and drought.

Wild types of endophyte produce alkaloids that can be harmful to livestock. Sheep and cattle grazing tall fescue dominant pastures infected with wild type endophytes are subject to tall fescue toxicity and fescue foot. These conditions are caused by the toxin ergovaline; it causes heat stress in animals by constricting the blood vessels. Other symptoms include severe lameness, reduced feed intake, and poor weight gains. Fortunately, the occurrence of

fescue toxicity and fescue foot in Australia are not common as current cultivars are low in or free of wild type endophyte. Some of the earlier varieties of tall fescue used in Australia (Alta, Kentucky-31 and Fawn) may contain wild type endophyte.

A recent development in tall fescue has been the development of non-toxic endophyte technology. Scientists have selected naturally occurring strains of endophytes that do not produce alkaloids toxic to livestock. The use of these non-toxic endophytes incorporated into adapted cultivars of tall fescue have been shown to improve plant water use, tillering, pest resistance, nutrient efficiency, persistence, drought tolerance and the mobility of aluminum in roots (Hoveland 2000). These non-toxic endophyte varieties are referred to as select or novel endophytes and are traded as Max P in Australia (Advance Max P, Jesup Max P, Quantum Max P, Flecha Max P, and Resolute Max P). Novel endophyte tall fescue varieties are relatively new to NSW and as such, there is limited data available on their performance and persistence in northern NSW. However, the reported increased tolerance of moisture stress and drought of these varieties has the potential to extend the zone of adaptation of tall fescue into lower more marginal rainfall areas of the Northern Tablelands and North-West Slopes that experience periodic summer droughts.

Tall fescue management

Most cultivars of tall fescue have poor seedling vigour resulting in slow establishment, although some of the newer varieties have improved seedling vigour. Grazing management during the first 12 months after sowing for both the temperate and Mediterranean varieties is particularly important to ensure a satisfactory plant population. Young stands of tall fescue should be grazed only when the root system is well developed and will not be pulled out of the ground. If sown late, surface sown or established under difficult conditions, delay grazing until flowering. If sown with a more vigorous grass species such as perennial ryegrass a seeding rate of <2 kg/ha of ryegrass is preferred. If weed competition is not a problem it is desirable not to graze tall fescue pastures until 6-8 months after sowing. However, if weeds are a problem, a registered herbicide or grazing management (heavy grazing for short periods to remove top growth of weeds) is recommended to reduce competition. Mediterranean varieties sown in autumn can be lightly grazed (to 10 cm) in spring to encourage tillering and reduce weed competitiveness.

Once established, tall fescue is able to tolerate heavy grazing. Grazing management should aim to prevent a build up of rank herbage. Where practical tall fescue pastures should be kept in the "active-growth" phase to maximise tillering, growth rate, quality, allow rapid post grazing recovery and encourage companion legumes.

For the temperate tall fescue types it is desirable to graze between dry matter limits of 800 and 2500 kg DM/ha (5-12 cm in height). This will generally require some form of rotational grazing particularly in a favourable spring and summer. During dry spells and drought, tall fescue pastures will require longer periods of rest to allow replenishment of energy reserves for regrowth. If tall fescue is allowed to set seed about every 3 years, seedling recruitment to increase paddock persistence and density will be favoured. During winter, temperate tall fescue can tolerate set stocking. Avoid tall, rank growth in late summer and early autumn to promote legume growth. Established tall fescue pastures should be heavily grazed strategically to prevent the formation of large erect tussocks with a high proportion of, low quality material.

Once the Mediterranean varieties are established, the pasture should be rotationally grazed over autumn and winter to promote tillering and allow companion annual legumes to germinate or in the case of perennial legumes, increase stolon density. During a favourable spring, established Mediterranean tall fescue can be continuously grazed at a high stocking rate but if the spring is dry, stocking rate will need to be reduced. Over summer, low stocking rates should be used to lightly graze tall fescue to promote bud activity and tiller development. Heavy stocking should be avoided; otherwise loss of plants will occur.

Tall fescue improvement programs

Tall fescue improvement in Australia dates back to the 1930s with the introduction of tall fescue germplasm by CSIRO that was released as cv. Demeter in the late 1950s (Hilder 1963). Mediterranean tall fescue material evaluated in Australia in the late 1960s (Neal-Smith and Wright 1969) resulted in the release of cv. Melik by the Western Australian Department of Agriculture in 1971.

Tall fescue improvement commenced at Glen Innes in 1993 with a collaborative project between

Agriculture Victoria and NSW Agriculture, supported by Meat & Livestock Australia. Tall fescue germplasm suitable for temperate and Mediterranean Australia was collected from World Genetic Resource Centres and included material from USA, USSR, Northern and Southern Europe, Northern Africa, and the Middle East. This collection has been strengthened with locally adapted material collected from old cv. Demeter pastures in northern NSW. From the Victorian component of the project a winter active, summer dormant cultivar (Fraydo) was released for southern Australia. Fraydo tall fescue (Venkatangappa and Jahufer 1998) is an early flowering cultivar developed from Melik. A summer active accession (AVH-12) for use in northern NSW was selected at Glen Innes. Being an accession, AVH-12 is not eligible for Plant Breeders Rights, but may be released by a commercial partner or used in future breeding projects.

With a few exceptions (e.g. phalaris), perennial grass improvement in Australia has focused on high rainfall, fertile conditions. The CRC for Plant-Based Management of Dryland Salinity project supported by Meat & Livestock Australia "*Perennial forage grass improvement for low-medium rainfall recharge environments to improve sustainability and profitability*" aims to develop adapted cultivars of tall fescue, cocksfoot and sub-tropical grasses for low to medium recharge environments. The tall fescue component of the project will be conducted on the North-West Slopes of NSW with sites at Inverell and Barraba, and will produce improved, drought tolerant, summer active tall fescue cultivars targeted at regions that receive significant summer rain, but experience periodic droughts limiting conventional cultivars.

Phalaris

Phalaris has been the most widely sown temperate perennial grass in NSW since its introduction to agriculture a century ago (Archer 1995). Reasons for its popularity include its productivity, drought survival, capacity to respond to increased soil fertility, deep root system, and lack of pests and diseases. Phalaris is a more drought-hardy species, better adapted to Slopes regions, than temperate tall fescue varieties. Mediterranean tall fescue varieties offer the promise of improved drought hardiness closer to that of phalaris (Fig. 1). Phalaris generally survives the heat and moisture stress of summer as dormant buds at the base of the stems. However, it can resume growth after summer rain particularly if accompanied by cooler weather. The summer-dominant rainfall of the North-West Slopes combined with relatively high temperature provides a challenge for phalaris survival.

Role of grazing management

Grazing management aimed at promoting dormant bud development in spring, maintenance of cover in summer and regeneration of buds in autumn can be expected to improve persistence. Winter active phalaris cultivars should be grazed rotationally through autumn and winter to maximise persistence and productivity. Lodge *et al.* (2003) showed that Sirosa phalaris grazed continuously at 12 sheep/ha persisted well at altitudes >500 m on the North-West Slopes when it was destocked for 6 weeks from the start of the autumn break and in spring (during stem elongation), or if stocking rate was reduced to 4 sheep/ha at these times. In contrast, the phalaris declined rapidly under year-round continuous grazing at 12 sheep/ha. These treatments refined an earlier demonstration of the benefit of seasonal closure for persistence of Sirosa (Lodge and Orchard 2000). However, seasonal reduction of grazing pressure did not improve persistence at a site around 430 m altitude (Lodge 2002).

Phalaris cultivars

Phalaris cultivars are divided mainly on the basis of winter growth activity. Semi-winter dormant cultivars have smaller seedlings, slower winter growth, good spread and grazing tolerance, and are more suited to continuous grazing on the Tablelands, e.g. cv. Australian. Winter-active cultivars have large seedlings, are more productive in the autumn-winter period, are best managed rotationally, and are suited to the Slopes and Tablelands e.g. cvs. Sirosa and Holdfast. Cultivars also vary in the strength of their basal bud dormancy; higher summer dormancy protects dormant buds from false breaks in hot summer areas.

Release of the winter-active cultivars resulted in considerable expansion of phalaris in both the cropping and high rainfall zones. Sirosa was developed for the Slopes and Tablelands and Sirolan was developed more specifically for the drier marginal areas more typical of the cropping zone, including the North-West Slopes. A highly summer-dormant cultivar, Sirocco, was also released for drier areas, but is no longer available. Sirolan and Sirocco persisted better than Sirosa and Australian during drought at Mendooran and Binnaway (Oram and Freebairn 1984).

Table 1. Grouping of phalaris cultivars

	Semi- winter-dormant	Winter-active		
		General purpose	Drier margins	Marginal soils (shallow, acid, low fertility)
Older cultivars	Australian Uneta Grasslands Maru	Sirosa	Sirocco Sirolan	
New seed-retaining alternatives	Australian II	Holdfast	Atlas PG	Landmaster

Table 2. Basal frequency (%) of phalaris cultivars sown in 1998 after 3 years of grazing at Tamworth and Manilla and 5 years of grazing at Purlewaugh

Cultivar	Basal frequency (%)		
	Tamworth	Manilla	Purlewaugh
Sirocco 67	23	43	
Sirolan	44	18	28
Atlas PG	34	19	23
Landmaster	38	33	20
Holdfast	33	21	21
Sirosa	37	15	9
Australian II *	2	5	6
Australian	36	23	6
Mean of top 10 accessions	83	58	*
l.s.d (P=0.05)	22	18	17

* Removal of plants from the persistent accessions prevented observations in 2003

Since 1990, 4 new cultivars of phalaris, Holdfast, Atlas PG, Landmaster and Australian II, have been released with a special mechanism of seed retention which has facilitated a stable supply of reasonably priced, good quality seed. These new cultivars, with the exception of Landmaster, are alternatives to older, non-seed-retaining cultivars, as shown in Table 1. Detailed information on phalaris cultivars can be obtained at www.pi.csiro.au/ahpc/grasses/grasses.htm.

Although Atlas PG and Sirolan were bred specifically for hotter and drier conditions typical of the northern cropping areas, recent persistence data from 3 sites on the Central and North-West Slopes suggest that all of the available winter-active cultivars are similar in persistence under grazing (Table 2). At 2 of the 3 sites, the highly summer-dormant but discontinued cv. Sirocco was the most persistent cultivar. Table 2 suggests a lack of longer term persistence without careful grazing management, but all the winter-active cultivars are highly suitable in a short term pasture phase in cropping rotations. Choice of companion legume was also shown to influence phalaris survival at these sites. Survival was higher with subterranean clover (*Trifolium subterranean*) than with the deeper-rooted lucerne, particularly on a light textured soil type at Manilla (Boschma and Culvenor 2002).

Cultivar development

Compared with southern areas, little phalaris cultivar development work has been conducted in either the North-West Slopes or Northern Tablelands. Atlas PG was selected partly on the basis of experimental results from Coolah and Merriwa and is recommended for the drier edges of the main phalaris belt and the cropping zone (Oram 1999).

In the last 2 decades, the CSIRO phalaris breeding program, with support from Australian Wool Innovation Ltd and Seedmark Pty Ltd, has worked increasingly towards producing cultivars better adapted to adverse conditions. Present priorities include the following breeding projects.

A cultivar with better persistence under grazing for longer-term pastures on the North-West Slopes. A breeding project specifically targeted at the North-West Slopes environment commenced in 1998 in collaboration with Dr S. Boschma, NSW Agriculture, Tamworth. Grazed studies were conducted at Purlewaugh, Manilla and Tamworth to evaluate persistence and other characters in 102 wild accessions, breeding populations and cultivars of phalaris. A major decline in plant survival occurred between 2000 and 2001 at Manilla and Tamworth, but not at Purlewaugh by 2001. Accessions with superior persistence at Manilla and Tamworth were identified (Table 2), most being in the best group at both sites. However, none of the selected accessions survived the 2002 drought year under close grazing at Manilla and Tamworth, reinforcing the importance of careful regulation of grazing pressure for persistence in this environment.

New breeding populations have been developed from some of the accessions after crossing with the most persistent seed-retaining population. These and several other breeding populations are to be tested under grazing at 2 sites in the Manilla area by Dr S.

Boschma, NSW Agriculture, from 2004-07. Parents of a new cultivar are due to be selected by late 2007 and a cultivar should be available several years later.

A new winter-active cultivar with improved persistence under heavy continuous grazing to overcome a lack of persistence of cv. Sirosa. Studies to select a more persistent winter-active cultivar for the main phalaris growing belt have recently been conducted in western Victoria, the Southern Tablelands of NSW and the North-West Slopes of NSW at Tamworth. The families tested in these studies have been selected for 2 generations on different soil types near Canberra. Positive linear response to selection was obtained at the 2 southern sites, but a negative response was obtained at Tamworth (Boschma, Reed and Culvenor unpublished). This emphasises the difference in environment between the North-West Slopes and more traditional phalaris-growing areas and indicates the need for a program specifically directed at the North-West Slopes. The new cultivar will be aimed mainly at more southerly locations.

A cultivar with improved tolerance of Aluminium (Al) for strongly acid soils and soils acid to depth. Soil acidity has been viewed as an important impediment to the use of phalaris on the Tablelands and in other States. An Acid Tolerant (AT) population produced in the last 20 years by CSIRO has markedly superior tolerance to Al in nutrient solution. Recent field studies suggest that the higher Al tolerance of AT phalaris confers a potential advantage in establishment on soil high in Al, but not long term persistence.

Conclusions

Summer rainfall on the North-West Slopes of NSW combined with high summer temperatures provides a challenging environment for introduced temperate perennial grasses. The establishment, growth and persistence of species such as phalaris, tall fescue, cocksfoot and perennial ryegrass has in the past been disappointing in this environment. Studies comparing the persistence of introduced grasses have indicated that phalaris and tall fescue are the most promising species for the Slopes regions of NSW. Until recently the varieties of tall fescue available to producers on the North-West Slopes have been limited to temperate types better suited to high rainfall, fertile environments more typical of the Tablelands. The release of more summer dormant tall fescue varieties may extend the use of tall fescue into the lower rainfall environments of the Slopes, but more experience of these varieties is needed to assess their persistence relative to that of phalaris. Studies examining the performance of a range of tall fescue and phalaris varieties (Lodge *et al.* 2004) should shed light on this comparison. Until then, winter-active phalaris cultivars (Atlas PG, Sirolan, Sirosa and Holdfast) probably remain the best adapted of the available long-lived temperate grass cultivars for the North-West Slopes.

Breeding projects for both phalaris and tall fescue specifically targeted at the North-West Slopes environment are currently underway. These projects aim to produce adapted and persistent cultivars for regions that receive significant summer rain but experience periodic droughts. While these grass species will mainly have impact in the permanent pasture zone, they also provide a perennial alternative to shallow rooted annual pastures in the pasture phase of phase farming systems. Strategic grazing management of the new varieties will remain an essential factor for the long term survival of phalaris and tall fescue pastures in the North-West Slopes environment.

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