Contributed papers

Phalaris cultivar persistence under soil fertility and grazing treatments at Canberra

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Abstract: *Increased intensity of pasture management through fertiliser input and increased stocking rates can increase the profitability of grazing enterprises but also places pressure on the persistence of perennial grasses. New winter-active cultivars of phalaris have been released with tolerance of a range of soil stresses (Landmaster, Advanced AT) and heavy grazing pressure (Holdfast GT). The persistence of these and older cultivars was tested over four years at a site near Canberra, under continuous and rotational stocking at high and low soil phosphorus (P) fertility, and reduced continuous stocking pressure at high soil fertility, to simulate on-farm management options. Basal frequency declined in the first year under low herbage masses accompanying drought. This decline was much less under rotational stocking or reduced grazing pressure than under continuous stocking. High P plots recovered partially or fully in the following high rainfall years but low P plots continued to decline. Holdfast GT persisted much better than other winter-active cultivars under continuous stocking and equally to the known grazing-tolerant cultivar, Australian, at high soil fertility. Australian was slightly better at low soil fertility. Persistence by Landmaster and Advanced AT was favoured by rotational stocking or reduced continuous stocking pressure. Holdfast GT was more productive in late winter at the end of the study due to its grazing tolerance and winter growth rate. Persistence of phalaris is best ensured by combining rotational management with high P nutrition but cultivars possessing grazing tolerance traits improve persistence under continuous grazing and when multiple stresses cause management to break down.*

Key words: Grazing management, perennial grasses, *Phalaris aquatica* L.

Introduction

Pasture improvement through phosphorus (P) application and growth of productive species has been an important avenue to increased animal production and profitability in southern Australia. The increase in stocking intensity required to maximise economic return on pasture improvement often results in a decline in the perennial grass component of pastures (e.g. Saul *et al.* 2009). Grazing management tactics are available to enhance the perennial grass component and hence sustainability of fertilised pastures (Kemp *et al.* 2000). However, Culvenor and Simpson (2014) concluded that the persistence of perennial grasses remains at risk when producers are unable to respond to concurrent stresses such as drought, overgrazing and soil acidity, and that the availability of cultivars with traits for improved persistence remained important.

Phalaris is a well-adapted and widely used perennial grass for improved pastures on the tablelands of New South Wales (Watson *et al.* 2000) but overgrazing, soil acidity and low soil fertility interacting with drought can reduce its persistence (Hutchinson and King 1999; Culvenor and Simpson 2014). Modern winter-active phalaris cultivars combine higher productivity potential than the semi-winter dormant Australian cultivar with higher seedling vigour, lower tryptamine alkaloid level and easier seed production. Nevertheless some growers prefer Australian because of the high priority they place on its grazing tolerance and persistence. Winter-active cultivars have now been bred for improved tolerance of soil-stress factors such as shallow, stony, moderately acidic soils (Landmaster) and strongly acidic soil (Advanced AT), and for improved grazing tolerance (Holdfast GT). It is currently advised to rotationally stock or tactically rest winter-active cultivars for good persistence (Watson *et al.* 2000) but the effect of grazing management has not been demonstrated for these cultivars and indeed may not be important for the persistence of Holdfast GT. We grew these and other cultivars at Canberra under a range of soil fertility, grazing management and grazing pressure treatments for four years that included low and high rainfall periods, to examine how (i) cultivar and management factors influence persistence and (ii) to assess the persistence of new and old cultivars under a range of soil fertility and grazing management.

Methods

Eight phalaris cultivars: Holdfast GT, Advanced AT, Landmaster, Sirosa, Holdfast, Atlas PG, Australian and Australian II, were grown in small plots embedded in the soil P × stocking rate experiment of Simpson *et al.* (2010) on the Ginninderra Experiment Station at Hall near Canberra (long term average rainfall 687 mm). The soil type was a yellow chromosol with a mean pHC_a of 4.4 from 0–20 cm soil depth. There were two entries of Holdfast GT (2 foundation generations) which were averaged since they did not differ, plus 7 breeding lines which are not reported here, giving a total of 16 entries that were actually sown. Fifteen sets (5 treatments × 3 replicates in a randomized block design) of 16 plots of these entries were sown in May 2007 in selected high P (target Olsen P 22.5 mg/kg from 0–10 cm) and low P paddocks (zero P application except for 100 kg single superphosphate at sowing, Olsen P 4 mg/kg). Plot size was 10 m^2 (7.4 m × 1.35 m) with 17 cm row spacing. Clover was not sown but the resident subterranean clover (Trifolium subterraneum L.) population re-established from its seedbank. Treatments were high P-high stocking rate (18 sheep/ha) rotationally stocked (HPRS) or continuously stocked (HPCS), high P-intermediate stocking rate (13.5/ha) continuously stocked (HPCS13.5), and low P-low stocking rate (9 sheep/ha) rotationally stocked (LPRS) or continuously stocked (LPCS).

Rotational paddocks were divided into 3 with the set of plots contained in 1 subdivision stocked 3 weeks on and 6 weeks off. Grazing treatments commenced in early June 2009 with young Merino wethers, which were replaced after 2 years. Paddocks were destocked when groundcover fell below about 75%, and this lowered stocking rates slightly. Forage mass in all treatments was measured every 9 weeks when the sheep were moved onto the rotational plots by cutting a 0.6 m × 0.09 m strip in each plot. These were bulked, sub-sampled, hand sorted into components, oven dried at 70°C and weighed. Basal frequency of phalaris entries was measured in June-July by counting the numbers of cells in 3 fixed quadrats of area 1 m × 0.75 m per plot divided into 75 cells, 0.15 m × 0.10 m in size, with the 0.75 m quadrat dimension placed across 5 drill rows. To assess the growth potential of the surviving phalaris at the end of the experiment in 2013, stock were excluded for a period in winter (7 June to 28 August) and spring (2 September to 30 October) and forage mass estimated by calibrated visual estimation and its components by Botanal in 8 quadrats per plot, each 0.5 m × 0.5 m in size. Herbage mass was collected every 9 weeks and basal frequency data for all 16 entries were analysed using the repeated measures analysis of variance procedures in Genstat 14.

Results and Discussion

Rainfall was below average in 2009 when grazing treatments commenced (544mm) with spring 2009 being particularly dry. Rainfall was above average in 2010 (1098 mm), 2011 (716 mm) and 2012 (894 mm) and close to average but with a dry autumn in 2013 (622 mm). High P treatments consisted mainly of phalaris, annual grasses and clover whereas the major component in low P plots was native perennial grass, either spear grass (*Austrostipa* spp.) or windmill grass (*Chloris truncata*). The spear grass was not grazed readily by the sheep, which increased grazing pressure on the phalaris and other components.

The period of lowest herbage mass occurred in spring-early summer 2009 with levels of total herbage DM (green plus dead) about 400 kg / ha by late October and green herbage mass near zero by mid-December in the continuously stocked treatments (HPCS, LPCS). Over the

4 years of the study, total herbage mass was usually in the range 900–2000 kg DM/ha. Average green herbage DM was highest pre-grazing in the HPRS (846 kg/ha) and LPRS (813 kg/ha) rotational treatments, intermediate for the HPCG13.5 treatment (738 kg/ha) and lowest for the LPCS (639 kg/ha) and HPCS (620 kg/ha) treatments. The phalaris proportion of green dry matter was higher on average under rotational stocking (HPRS, LPRS) than continuous stocking (HPCS, LPCS; 40% vs. 17%) and was higher at high soil P (HPRS, HPCS) than low soil P (LPRS, LPCS; 35% vs. 23%). Nitrogen in this experiment was supplied by the subterranean clover component, which itself was influenced by treatment. Average clover content over four years was 10%, 23%, 25%, 7% and 13% for the HPRS, HPCS, HPCS13.5, LPRS and LPCS treatments, respectively. Peak spring clover content averaged 26%, 50%, 45%, 19% and 34% for the same treatments, respectively.

Basal frequency averaged across all entries declined most in the first year in the continuously stocked treatments irrespective of P treatment (HPCS, LPCS) and least in the high-P rotational (HPRS), high P-intermediate continuous stocking rate (HPCS13.5) and low P-rotational (LPRS) treatments (Fig. 1). All high P treatments partially or fully recovered in the following higher rainfall years, whereas the low P treatments continued to decline gradually irrespective of grazing management (Fig. 1). Recovery at high P was observed to be due to vegetative expansion of surviving plants rather than seedling recruitment. After 4 years, the effect of rotational stocking at high P and high stocking rate was similar to reducing the rate of continuous stocking at high P by 25% (13.5 vs. 18 sheep/ha)

Holdfast GT survived the early period of overgrazing in the HPCS treatment better than all other cultivars (Table 1). Australian and Australian II declined more than Holdfast GT but recovered to form a more persistent group with Holdfast GT. Winter-active cultivars other than Holdfast GT declined severely in the first year to form a lower basal frequency group thereafter (Table 1). For these winter-active cultivars, persistence under high P was much improved by rotational stocking (HPRS) or by reducing the rate of continuous stocking to 13.5 sheep/ha (HPCS13.5; Table 1). Advanced AT and Landmaster have higher aluminium tolerance than other phalaris cultivars (Culvenor *et al.* 2011). They persisted better in the HPRS and HPCS13.5 treatments than Sirosa and Atlas PG suggesting that soil acidity may have been a factor in the differences. The better persistence at high P resulting from grazing management supports recommendations

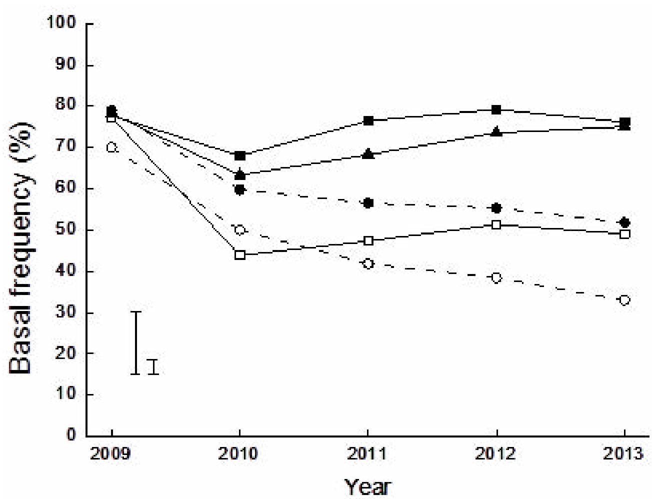

Figure. 1. Basal frequency averaged over 16 phalaris entries for the HPRS (■), HPCS (□), HPCS13.5 (▲), LPRS (●), and LPCS (○) treatments from 2009–13. The left-hand error bar indicates lsd (P=0.05) between treatments; the right-hand error bar indicates lsd (P=0.05) between years for the same treatment.

that winter-active cultivars be rotationally stocked for better persistence under grazing. However, Holdfast GT is much more tolerant of continuous stocking. Persistence under low P was generally improved with rotational stocking but basal frequency continued to decline in both grazing management treatments. Australian was the most persistent cultivar but was not significantly better than Holdfast GT and Landmaster. Sirosa, Holdfast and Alas PG were least persistent under continuous stocking at low P.

In late August 2013, after four years of grazing treatments and 82 days of exclusion from grazing, phalaris herbage mass averaged 1157 kg/ha at high P compared with 321 kg/ha at low P, and total herbage mass averaged 1816 kg/ha at high P compared with 1052 kg/ha at low P (data not shown). Phalaris herbage mass was related to basal frequency in all treatments (range in r = 0.64–0.94, P<0.01). Cultivar differences occurred at high P (Table 2) but not at low P (not shown). Holdfast GT was the highest yielding winter-active cultivar under the higher rate of continuous stocking (HPCS), and higher than Australian because of its inherently higher winter growth rate at a similar basal frequency (Table 2). Compared with the mean of the main alternative cultivars to Holdfast GT (Holdfast, Landmaster, Sirosa, Advanced AT),

Table 1. Basal frequency in years 1, 2 and 5 (2009, 2010, 2013) for 8 phalaris cultivars under 5 treatments, high P-high stocking rate rotationally stocked (HPRS) and continuously stocked (HPCS), high P-intermediate stocking rate continuously stocked (HPCS13.5), and low P-low stocking rate rotationally stocked (LPRS) and continuously stocked (LPCS).

Cultivar	HPRS			HPCS			HPCS13.5			LPRS			LPCS		
	Yr1	Yr2	Yr5	Yr1	Yr2	Yr5	Yr1	Yr2	Yr5	Yr1	Yr2	Yr5	Yr1	Yr2	Yr5
Holdfast GT	87	79	87	87	63	63	75	73	86	86	69	59	76	62	45
Advanced AT	72	58	73	75	22	27	74	61	78	75	52	41	72	38	24
Landmaster	72	58	76	69	18	24	87	71	81	84	63	47	68	52	37
Sirosa	66	54	59	66	30	41	67	35	49	66	40	34	56	27	13
Holdfast	80	66	69	71	31	39	82	50	62	76	53	44	62	33	18
Atlas PG	70	53	52	75	37	39	75	52	53	75	51	38	65	33	18
Australian	79	68	77	79	46	62	83	68	85	84	76	72	80	72	50
Australian II	76	70	80	74	37	52	84	69	83	74	49	44	71	52	35

lsd (P=0.05) between cultivars in same treatment = 23; between years for the same treatment and cultivar = 14.

Table 2. Phalaris and total herbage mass (kg DM/ha) in late August 2013 for 8 cultivars after 4 years of grazing treatments at high P when sampled after 82 days of exclusion from grazing.

Cultivar	Phalaris herbage mass			Total herbage mass		
	HPRS	HPCS	HPCS13.5	HPRS	HPCS	HPCS13.5
Holdfast GT	1333	1231	1448	1918	1785	2196
Advanced AT	1147	777	1544	1806	1443	2244
Landmaster	1506	692	1245	2105	1498	1966
Sirosa	1061	882	1094	1688	1633	1928
Holdfast	1022	731	1174	1603	1354	1886
Atlas PG	1019	746	1068	1645	1451	1920
Australian	954	1002	1231	1508	1525	1823
Australian II	1017	842	1279	1578	1498	1915
lsd (P=0.05)*		338			260	

* The lsd values are for differences between cultivars within treatments.

Holdfast yielded 60% more phalaris herbage and 20% more total herbage at this time of year, when extra feed is of high value. Significant differences between cultivars at high P were fewer under rotational stocking (HPRS), where Landmaster was the highest yielding cultivar but not significantly higher than Holdfast GT. Advanced AT was the highest yielding cultivar under reduced continuous stocking pressure (HPCS13.5) but not significantly higher than several other cultivars (Table 2). After mowing and a further period of exclusion up to late October, Holdfast GT and Australian or Australian II again had the highest yield of phalaris herbage in the HPCS treatment and Landmaster had the highest yield under rotational stocking (HPRS), but there were few differences in total herbage mass due to the higher contribution from annual grasses and clover (data not shown).

Conclusions

Higher soil fertility improved the ability of phalaris to partially recover basal frequency after an initial decline due to overgrazing in drought. Persistence of all cultivars was improved by rotational compared with continuous stocking but Holdfast GT was the most persistent of the winter-active cultivars under continuous stocking and was similar to Australian over four years. It is recommended that Advanced AT and Landmaster be rotationally stocked for good persistence at high grazing pressure although this requirement can be relaxed if grazing pressure is substantially reduced. However, this will mean foregone income. Persistence of phalaris is best ensured by combining rotational management with high P nutrition. However, cultivars such as Holdfast GT, which possess grazing tolerance traits, improve persistence under continuous stocking and multiple stresses (e.g. drought, heavy grazing) which growers may find difficult to manage.

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