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Other research

Benefits of lucerne/perennial grass mixtures in cropping rotations

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Key findings

- The most productive pasture swards over five years were sown to a mixture of phalaris, lucerne and sub clover.
- Only swards that included phalaris maintained groundcover >70% in all years, including periods of drought.
- Phalaris swards reduced annual grass weed incursion through competition by up to 7-fold compared with pure legume swards.
- Lucerne/perennial grass mixtures produced ~35% more legume biomass than swards sown only to sub clover.
- Lucerne's winter activity had little effect on its productivity and persistence.

Introduction

Cultivars of phalaris and cocksfoot, well-suited for use in crop rotations in drier environments, were first released in southern Australia during the 1970s. Cereal grain yields, after a perennial grass-based pasture phase, are comparable with pastures based on lucerne or annual legumes (Dear et al. 2004). In spite of this, few perennial grass species are used across the grain belt of south-eastern Australia.

A five-year field experiment was conducted near Ariah Park to assess the compatibility of temperate perennial grasses grown in mixtures with lucerne and/or sub clover in a typical medium rainfall cropping environment, and to assess the effects on productivity, ground cover and grass weed incursion attributable to the perennial grass.

This paper is a summary of a more detailed report that was recently published following the conclusion of this experiment (Hayes et al. 2018).

Site details

Location	15 km north of Ariah Park
Soil type	Brown dermosol
Experiment period	Sown 7 May 2010; final sampling of herbage mass, June 2014.
Annual rainfall	2010 – 745 mm; 2011 – 675 mm; 2012 – 569 mm; 2013 – 366 mm; 2014 – 414 mm. Long-term annual average for that site – 475 mm.

Treatments

The experiment included 18 treatments with three replicates. Plot size was 6 × 4 m. There were six perennial grass treatments sown in mixtures with one of three legume combinations.

Perennial grass cultivars and sowing rates

Three phalaris cultivars and two *Hispanic* cocksfoots were compared with pure legume treatments (nil perennial grass) (Table 1). Phalaris was sown at 2.5 kg/ha, or at 1.5 kg/ha in mixtures with lucerne. Cocksfoot was sown at 3 kg/ha, or at 1.8 kg/ha in mixtures with lucerne.

Legume cultivars and sowing rates

All treatments were sown with a mixture of the annual legumes subterranean clover at 2.7 kg/ha (cvv. Seaton Park and Urana in equal proportions by weight), and eastern star clover cv. Sothis at 1.3 kg/ha. Lucerne cultivars with high winter activity and low winter activity (in equal proportions by weight) were compared with nil lucerne (annual legume only or annual legume/perennial grass mixture) treatments. Lucerne was sown at 2.5 kg/ha, or at 1.0 kg/ha in mixtures with a perennial grass.

Table 1. Description of cultivars sown in the experiment.

Species	Cultivar/line	Description
Phalaris (*Phalaris aquatica* L.)	Atlas PG	Winter-active perennial habit with substantial but incomplete summer dormancy
	Holdfast	Relatively summer-active, later maturing and with low levels of summer dormancy
	Sirolan	Relatively summer-active, earlier maturing and with low levels of summer dormancy
Cocksfoot (*Dactylis glomerata* L. ssp. *hispanica* Roth.)	Kasbah	Winter-active perennial habit with complete summer dormancy
	Moroccan	Winter-active with high level of summer dormancy
Lucerne (*Medicago sativa* L.)	Stamina 5	Low winter-activity (LWA) rating (5)
	Venus	Low LWA rating (5)
	54Q53	Very low LWA rating (3)
	SARDI 10	Very high LWA rating (9–10)
	Silverado	Very high LWA rating (9)
	Cropper 9.5	Very high LWA rating (9.5)
Subterranean clover (*Trifolium subterraneum* L.)	Urana	Winter-growing annual habit, mid-season maturity, delayed seed softening characteristics
	Seaton Park	Winter-growing annual habit, early–mid-season maturity, low hard seed levels
Eastern star clover (*Trifolium dasyurum* C. Presl)	Sothis	Winter-growing annual habit, early–mid-season maturity, delayed seed softening characteristics

Results

Pasture productivity and composition

Sirolan phalaris yielded the highest cumulative dry matter (DM) during the experiment period and yielded significantly more grass biomass than Atlas PG phalaris and both cocksfoots (Table 2). The lucerne productivity more than doubled when perennial grasses were excluded from the mix, in part reflecting the higher sowing rates of lucerne in those treatments. There was no difference in biomass contributed by other legumes among all treatments, which predominantly comprised naturalised burr medic. Cumulative weed biomass was generally least in mixes that included phalaris.

Table 2. Cumulative herbage dry matter (t/ha) under different pasture mixes over five years.

Species	Cultivar	Lucerne winter activity	Cumulative herbage dry matter (t/ha)					
			Perennial grass	Lucerne	Sown annual legume	Other legumes	Weeds	Total DM
Phalaris	Atlas PG	High	16.4	8.0	2.4	7.0	5.9	39.8
		Low	14.9	6.3	1.9	7.5	4.7	35.3
		Nil	19.8	–	4.5	3.2	5.7	33.3
Phalaris	Holdfast	High	18.4	7.1	4.0	4.2	4.3	38.0
		Low	17.5	6.2	2.2	8.0	3.8	37.7
		Nil	23.0	–	3.1	7.2	3.7	37.1
Phalaris	Sirolan	High	21.3	7.4	2.2	6.6	4.9	42.5
		Low	20.1	8.1	2.2	6.2	4.2	40.9
		Nil	26.9	–	2.8	4.8	4.3	38.7
Cocksfoot	Kasbah	High	6.1	7.4	3.5	5.8	9.2	32.1
		Low	6.5	8.3	3.1	5.5	6.7	29.9
		Nil	10.9	–	4.1	5.7	6.6	27.3
Cocksfoot	Moroccan	High	6.7	7.3	2.7	8.3	6.2	31.1
		Low	6.7	7.8	2.4	8.5	5.3	30.7
		Nil	10.6	–	2.8	8.5	5.3	27.2
Lucerne	Nil	High	–	17.2	3.5	7.6	7.3	35.6
		Low	–	14.2	3.4	7.5	7.0	32.1
Subclover	Nil	Nil	–	–	5.7	5.2	10.7	21.7
l.s.d. ($P = 0.05$)			5.14	4.18	1.88	–	2.54	4.77

Ground cover

Ground cover in autumn during years two, three and five was generally between 80% and 95% for all treatments. The proportion of exposed bare soil, the converse of ground cover, was highest for all treatments in year four, reflecting the drier seasonal conditions from September 2012 to April 2013 and ranged between 25% and 38% (Figure 1). During that period, only the treatments that included phalaris remained above 70% total ground cover. Throughout the experiment period, autumn ground cover was usually lowest in the pure legume or Moroccan cocksfoot treatments, although this trend was reversed in the final year due to the early emergence of annual grass weeds.

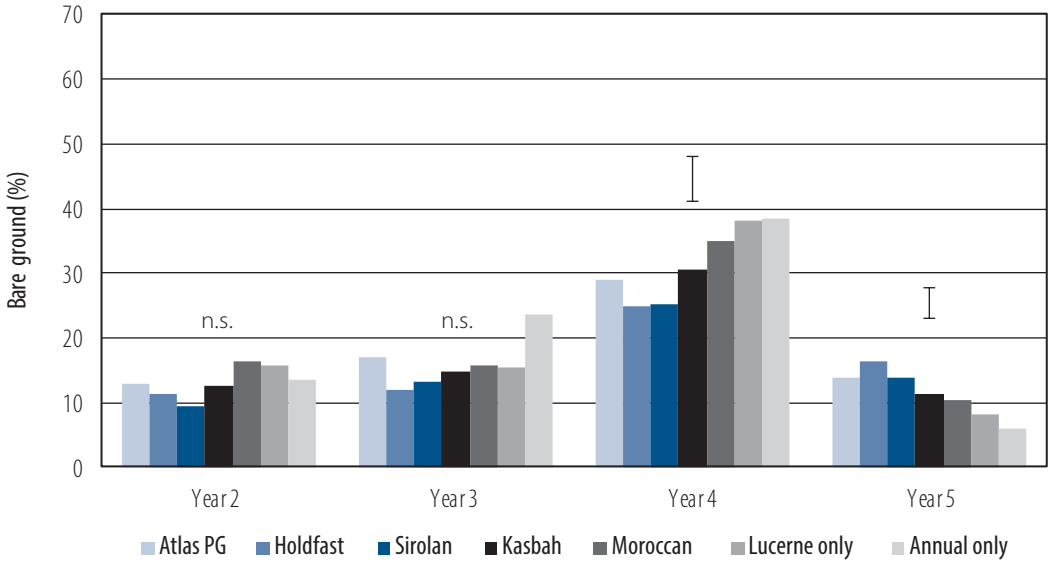

Figure 1. Bare ground under different pasture mixes sampled in autumn in years 2–5 (2011–2014). Vertical bar represents least significant difference between treatment means at $P = .05$; n.s. indicates no significant difference ($P>0.05$).

Annual species regeneration

Regeneration of sub clover peaked in year two ranging between 360 plants/m^2 and 1,200 plants/m^2 across all treatments, with density observed to be roughly double in the nil grass treatments compared with the phalaris swards; it was generally intermediate in the cocksfoot swards. Regeneration of eastern star clover beyond year one was negligible throughout the experiment period. Burr medic seedling regeneration peaked in year five with all treatments observed to have over 700 plants/m^2 emerging in autumn 2014.

Regeneration of the naturalised burr medic was generally highest in the Moroccan cocksfoot swards during the experiment. The density of annual grass weed seedlings emerging in the final year of experimentation differed according to pasture treatment. Annual grass weed incursion was generally lowest in the cvv. Sirolan (average 173 plants/m^2) and Holdfast (200 plants/m^2) phalaris swards, and highest in the treatments not containing a perennial grass. Density was more than double in the annual-only treatment (1,262 plants/m^2) compared with the lucerne-only treatments (558 plants/m^2), but lucerne winter activity had little effect on annual grass weed invasion.

Discussion

More diverse mixtures are commonly shown to be more productive due to enhanced resource-use efficiency, particularly where multiple functional plant types (e.g. legumes and grasses; annuals and perennials) are represented (Picasso et al. 2011).

This study showed that pasture productivity and persistence was maximised where a mixture of well-adapted cultivars from multiple species was included in the sward. In all cases, total cumulative biomass was reduced where lucerne was excluded from the perennial grass-based swards. The annual-only sward, which excluded all perennial species, was the least productive sward over the life of the experiment by a considerable margin.

Our experiment demonstrated that adding Sirolan phalaris increased cumulative pasture biomass by up to 25% compared with lucerne/clover pastures, and almost doubled biomass production compared with the annual legume sward. This demonstrates a significant opportunity for farmers in similar environments to increase pasture productivity by adding phalaris to their existing lucerne pastures in cropping rotations. The experiment also demonstrated a decreased annual grass weed burden following five years of a Sirolan phalaris-based pasture. The number of annual grass weeds emerging at the end of the pasture phase was between threefold and sevenfold greater in lucerne-based and

annual legume-based swards, respectively, compared with the Sirolan phalaris swards due to reduced competition of grass weeds by the legumes. Moreover, only the phalaris treatments were able to maintain >70% ground cover in autumn of every year during the experiment period.

Most of the perennial grass/annual legume swards generated a similar amount of cumulative legume biomass over the experiment period (~10 t/ha) to that observed in the annual legume pasture sward. Including perennial grasses therefore might not necessarily represent a compromise in biological nitrogen inputs when compared with pure annual legume pastures. The Sirolan phalaris/annual legume swards were an exception, only producing ~7 t/ha of legume biomass, most of which comprised the naturalised burr medic. The reduced legume productivity in this treatment is undoubtedly attributed to the increased competition by cv. Sirolan, which has previously been demonstrated to be a strong competitor with annual species such as subterranean clover (Dear et al. 1998).

When lucerne was added to the perennial grass swards, cumulative legume biomass increased to ~16 t/ha, approximately 35% more than that observed in the annual legume sward. This clearly demonstrates the great potential to increase legume biomass in a perennial grass-based pasture simply by adding lucerne, although legume biomass in these treatments was not as great as the ~25–28 t/ ha of cumulative legume biomass observed in lucerne swards without a perennial grass.

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