Success of perennial pasture establishment at different sowing times and under a cover crop in the mixed farming zone

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Abstract

Incorporating perennial pastures into cropping systems can improve whole farm productivity, profitability and sustainability of mixed farming systems in southern Australia. However, the success in establishment of perennial pastures is dependent on the choice of species, establishment methods and seasonal conditions. A series of field experiments sown from 2008 to 2010 aimed to determine the effects of time of sowing and the impact of a cover crop on the performance of 4 perennial pasture species, lucerne (*Medicago sativa*), chicory (*Cichorium intybus*), phalaris (*Phalaris aquatica*) and cocksfoot (*Dactylis glomerata*) at Yerong Creek, New South Wales. Results showed that perennial pastures can be established either in autumn or spring without cover cropping. Under favourable seasonal conditions, such as in 2010, lucerne and chicory pastures produced 29 and 23 t DM/ha, respectively, for the autumn-sown pastures, but only 20 and 15 t DM/ha, respectively, for the spring-sown pastures in their second growing season. However, spring-sown pastures had no or very low proportion of subterranean clover (*Trifolium subterraneum*) in the sward. It is recommended that perennial pastures should be sown in autumn rather than in spring until such time as methods to reliably establish annual legumes in spring are developed and tested. Establishing pastures in autumn under a cover crop was successful in a wet year, such as 2010, but was not satisfactory or failed in dry years.

Introduction

In the mixed farming zone of southern New South Wales (NSW) where average annual rainfall is 450-600 mm, farm enterprises comprise a combination of cropping and livestock activities typically in a phased rotation. Pastures play an important role in supplying livestock feed and restoring soil fertility. Lucerne (*Medicago sativa*) is the dominant perennial pasture species grown throughout the region. Although widely grown, its more extensive use is limited by susceptibility to acid soils (Bouton 1996), waterlogging (Real *et al.* 2008) and poor persistence under set stocking (Leach 1978). Concerns with animal health issues arising from grazing pure lucerne, such as bloat and redgut, also prevent some farmers from expanding the area sown. Other perennial pasture species potentially adapted to parts of the region include chicory (*Cichorium intybus*) and perennial grasses such as phalaris (*Phalaris aquatica*), tall fescue (*Festuca arundinacae*) and cocksfoot (*Dactylis glomerata*) (Dear *et al.* 2008).

Incorporating perennial pastures into cropping systems can improve whole farm productivity, profitability and sustainability in mixed farming systems in southern Australia. However, the success of establishment of perennial pastures is dependent on the choice of species, establishment methods and seasonal conditions. A survey of 97 producers in uniform rainfall region in southern NSW indicated that cover cropping was the most common method of establishing pastures with up to 83% of farmers using this technique (Li *et al.* 2010). However, pasture establishment with cover cropping had proved to be unreliable under the variable climatic conditions experienced over the past decade. The reliability of pasture establishment was seen as a major impediment to increasing the area sown to perennial pasture species. Hence the objective of this study was to determine the effects of time of sowing and the impact of a cover crop on the performance of perennial pasture species in terms of establishment, persistence and pasture DM production in the mixed farming zone of southern NSW.

Materials and Methods

Three field experiments adjacent to each other were established at Yerong Creek, NSW in 2008 (Experiment 1), 2009 (Experiment 2) and 2010 (Experiment 3). The soil at the site was a Red Kandosol (Isbell 1996). Soil pH in 1 M KCl was 4.5 in 0-10 cm and 4.1 in 10-20 cm. The long-term average annual rainfall was 549 mm. It was extremely dry in 2008 (396 mm) and 2009 (338 mm), but received well above average rainfall in 2010 (880 mm) and 2011 (810 mm).

Four types of pastures were sown either in autumn with and without a cover crop, or in late winter/early spring (Table 1). Subterranean clover (*Trifolium subterraneum*) was sown with perennial species for all autumn-sown treatments, including under-sown pastures. Subclover seeds were broadcasted in the following autumn for spring-sown pastures. There were 12 treatments with 3 replicates in a complete randomized design. Plot size was 4 × 12 m.

Establishment counts were conducted 8 weeks after sowing. Basal frequency (presence of crown or stem base in 10 × 10 cm grids in a 1m^2 quadrat) of perennial species was monitored in 2 fixed quadrats in autumn each year from year 2 onwards as an indication of persistence. Pasture DM production was visually estimated at each season and calibrated using 10 quadrat cuts (r^2 > 0.8, P < 0.05). Botanical composition was measured using the dry weight rank method (t' Mannetje and Haydock 1963) whenever pasture DM was assessed. All data were subjected to appropriate analysis of variance conducted in GenStat Release 14.1.

Table 1 Treatment description and sowing rates

Autumn-sown	Spring-sown	Under-sown in autumn[B]	Sowing rate
Lucerne/subclover[A]	Lucerne	Wheat + Lucerne/subclover	Aurora lucerne at 5 kg/ha
Chicory/subclover	Chicory	Wheat + Chicory/subclover	Puna chicory at 4 kg/ha
Phalaris/subclover	Phalaris	Wheat + Phalaris/subclover	Atlas PG phalaris at 5 kg/ha
Cocksfoot/subclover	Cocksfoot	Continuous crops	Kasbah cocksfoot at 4 kg/ha

[A]Subclover was sown as a mix of cvv. Riverina (3 kg/ha), Coolamon (2 kg/ha) and Seaton Park LF (2 kg/ha).
[B]Ellison wheat sown as a cover crop at 20 kg/ha, and as a straight sown crop at 70 kg/ha.

Results

There was a significant interaction in establishment densities between pasture species, sowing time and sowing methodology for all 3 experiments (P < 0.05). Averaged across 3 experiments, lucerne and chicory had the highest seedling density in spring-sown pastures (58 and 61 plants/m^2, respectively), and the lowest when under-sown in autumn (21 and 28 plants/m^2, respectively). In contrast, phalaris and cocksfoot had higher seedling density in autumn-sown pastures (133 and 75 plants/m^2, respectively) than in spring-sown pastures (90 and 68 plants/m^2, respectively). Under-sown phalaris had the lowest seedling density (76 plants/m^2) among all phalaris treatments (data not shown).

Basal frequency decreased from years 2 to 3 for all treatments except for chicory sown in autumn where basal frequency increased slightly in Experiment 1 (Table 2), but increased from years 2 to 3 for all treatments in Experiment 2 in response to high rainfall in 2010 and 2011. Relatively, basal frequencies of all perennials other than phalaris on the spring-sown pastures were more than doubled in year 3 compared to those in year 2, and basal frequencies of lucerne and chicory increased by 118% and 254% on the under-sown pastures from years 2 to 3 in Experiment 2. This large increase was due to the low initial basal frequency which increased with favorable seasonal conditions the following year.

Lucerne was the most productive pastures followed by chicory either sown in autumn or spring, or under-sown with a cover crop in Experiments 1 and 2 (Fig. 1*a*, *b*). In Experiment 3, pasture DM in year 1 was 17 and 15 t/ha for chicory and phalaris, respectively, which was higher than lucerne (9 t/ha) for

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the autumn-sown pastures (Fig. 1*c*). In year 2 of Experiment 3, spring-sown lucerne and chicory pastures had much higher DM production than those in year 1, while cocksfoot pasture produced negligible DM. For under-sown pastures, lucerne, chicory and phalaris pastures produced approximately 10 t/ha in year 2 (Fig. 1*c*). The highest pasture DM was obtained in year 2 in Experiment 2 where lucerne pasture yielded 29 t/ha and chicory pasture yielded 23 t/ha. Overall autumn-sown pastures produced more dry matter than under-sown pastures and often but not always they produced more than spring sown pasture.

Subclover was present in very low proportions in swards of spring-sown pastures (Fig 2). For autumn-sown pastures, subclover content was higher in chicory, phalaris and cocksfoot pastures than in lucerne, especially in Experiments 1 and 2. For under-sown pastures, the proportion of chicory was negligible in Experiment 1, and phalaris was negligible in both Experiments 1 and 2. Under-sown lucerne represented a reasonable proportion of the sward in Experiments 1 and 2 (Fig 2).

Table 2 **Persistence measured as basal frequency (%) over 3 years for pastures sown in 2008 and 2009**

Treatment	Experiment 1 (sown in 2008)			Experiment 2 (sown in 2009)		
Autumn-sown	Year 2	Year 3	Changes	Year 2	Year 3	Changes
Lucerne	45.8	33.0	-28%	16.0	27.5	72%
Chicory	7.0	8.5	21%	16.2	24.2	49%
Phalaris	54.5	9.5	-83%	16.9	28.5	68%
Cocksfoot	29.5	6.8	-77%	17.4	24.5	41%
Spring-sown						
Lucerne	57.0	38.2	-33%	9.8	24.7	151%
Chicory	21.5	12.3	-43%	11.3	23.5	109%
Phalaris	42.3	16.1	-62%	9.4	15.0	59%
Cocksfoot	26.0	17.8	-32%	1.7	6.5	290%
Under-sown						
Lucerne	6.2	4.8	-23%	6.4	14.0	118%
Chicory	7.2	0.3	-97%	4.0	14.2	254%
Phalaris	3.2	1.7	-47%	4.9	8.7	76%

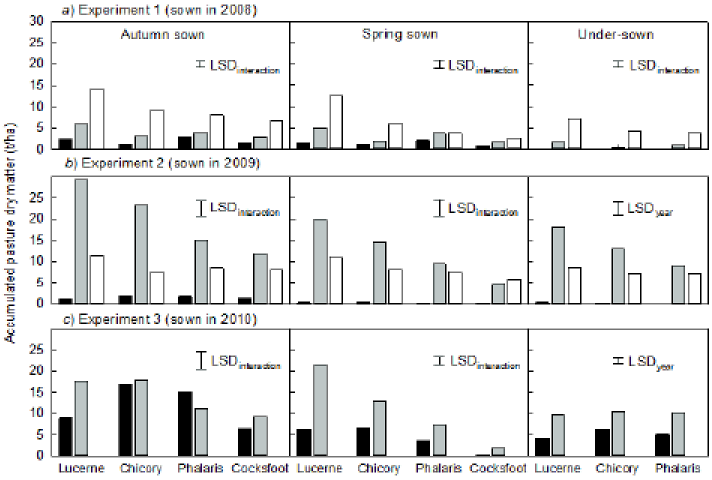

Fig. 1 **Accumulated pasture dry matter (t/ha) for sown species in year 1 (▪), year 2 (▫) and year 3 (▫) in *a*) Experiment 1 sown in 2008; *b*) Experiment 2 sown in 2009 and *c*) Experiment 3 sown in 2010 (only**

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two years of data presented).

Discussion

Results demonstrated that perennial pastures can be established either in autumn or spring. Lucerne was the most productive pasture followed by chicory. Phalaris and cocksfoot had high establishment counts, indicating successful establishment, but were not as productive as lucerne or chicory. Under favourable seasonal conditions, lucerne and chicory pastures produced 29 and 23 t DM/ha, respectively, when sown in autumn (Fig. 1), but only 20 and 15 t DM/ha, respectively, when sown in spring in their second growing season. One of the advantages of sowing pastures in spring is to have more opportunity to control winter weeds, but there are difficulties in including annual legume species into the established pastures in subsequent years. There was virtually no subclover in swards for 2 of the 3 experiments during the pasture phase despite efforts to broadcast seeds at the break of season in autumn in year 2. The major value of including a pasture phase in phased farming systems is to increase soil N for the crop rotation. The quantity of N fixed by legumes is closely related to legume DM accumulation (Peoples and Baldock 2001). Therefore, it is recommended that perennial pastures should be sown in autumn rather than in spring in the medium and high rainfall region.

The success of under-sown pastures was very season-dependent. The establishment of perennial pastures was unsatisfactory or failed under a cover crop in dry years (2008 or 2009). In contrast, perennial pasture establishment was successful in a wet year (2010) where pasture can be as productive as spring-sown pastures from its second growing season. This finding is consistent with the conclusion from survey results in uniform rainfall region in southern NSW (Li *et al.* 2010).

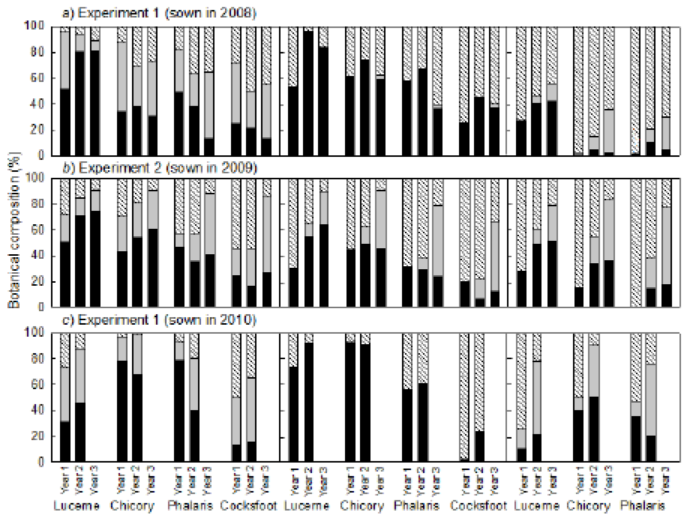

Fig. 2 Pasture botanical composition for sown perennial species (), subclover () and weeds () in *a*) Experiment 1 sown in 2008; *b*) Experiment 2 sown in 2009 and *c*) Experiment 3 sown in 2010 (only two years of data up-to-date). The first bar in each treatment is for the botanical composition in year 1, and the second bar in year 2 and the third bar in year 3.

Acknowledgements

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