The search for alternative perennial pasture legumes adapted to the changing climatic conditions across Tasmania's low to medium rainfall region

Eric Hall[1] and Andrea Hurst[1]

[1] Tasmanian Institute of Agricultural Research, PO Box 46, Kings Meadows, Tasmania 7249, Australia. http://www.tiar.tas.edu.au/ Email: Eric.Hall@utas.edu.au

Abstract

In response to the need to find better adapted and more persistent perennial legumes for dryland pastures in cool temperate low to medium rainfall (500-750 mm) regions, 24 species of perennial legume were monitored for persistence under sheep grazing at two replicated sites in Tasmania. The sites: Cressy, annual average rainfall 628 mm and Jericho, annual average rainfall 570 mm are representative of the target region. Results based on frequency measurements collected over a five-year period show large differences in the persistence of the species monitored. Lucerne (*Medicago sativa* L.subsp. *sativa*) was the only control species with the ability to adapt to the environmental conditions at both sites with a combined site frequency of 60. White clover (*Trifolium repens* L.), a species commonly sown in the low to medium rainfall region failed to survive at both sites. The work identified three alternative species in Talish clover (*Trifolium tumens* Steve. ex M.Bieb.), *Trifolium ambiguum* M.Bieb.) and lucerne x yellow lucerne hybrid (*Medicago sativa* L.subsp. *sativa* x *Medicago sativa* L. *subsp. falcata* (L.) Arcang.) as well adapted to the environmental conditions. These species recorded frequencies equal to or better than the best control species *M. sativa subsp. sativa* at both sites. Other alternative species worthy of further consideration include *Trifolium physodes* Steve. ex M.Bieb., sulphur clover (*Trifolium ochroleucum* Huds.) and birdsfoot trefoil (*Lotus corniculatus* L.) The poor performance of the control species *T. repens,* strawberry clover (*Trifolium fragiferum* L.) and red clover (*Trifolium pratense* L.), highlighted the inability of these commonly sown species to adapt to this drought prone environment and the need to develop and commercialise well adapted alternative species.

Keywords

Drought tolerance, adaptation, persistence, temperate pastures

Introduction

The four most important perennial legume species used in grazing systems across Tasmania's low to medium rainfall (500-750 mm) region are white clover (*Trifolium repens* L.), red clover (*Trifolium pratense* L.), strawberry clover (*Trifolium fragiferum* L.) and lucerne (*Medicago sativa* L.subsp. *sativa*). In the target rainfall zone, all of these species have adaptational deficiencies limiting their persistence. *T. repens* is at its natural limit of climatic adaptation, performing best in areas receiving > 700 mm mean annual rainfall (Dear and Ewing, 2008). *T. pratense* has a low tolerance to moisture stress and will not survive long, dry summers. *T. fragiferum,* is more drought tolerant than *T. repens* (Dear et al. 2003), but is best adapted to wet or saline soils and will not survive long, dry summers, while the persistence and use of *M. sativa* subsp. *sativa* is restricted by factors including water logging, acid soils and unfavourable grazing management. The contribution of subterranean clover (*Trifolium subterraneum* L.), the most important annual legume used in the target area has also decreased dramatically over recent years, largely due decreasingly reliable autumn rainfall across the region. Across Tasmania between 1997 and 2007 autumn rainfall suffered a 12% reduction relative to historical climate data (CSIRO 2009).

During the last 20 years mean annual rainfall in the target area has decreased by approximately 20%. Oatlands situated 5km north of the Jericho evaluation site has a mean annual rainfall of 553 mm and a winter average of 137 mm from more than 100 years of records. During the decade from 1991 to 2000 Oatlands recorded below average rainfall every year (Pook 2001). The effects of these low rainfall winters have been felt in the subsequent summers and the cumulative effect has seen a decline in the production and persistence of traditionally grown perennial pasture species resulting in a steady decrease in the stock carrying capacity of the region.

Attempts to find alternative perennial legumes for temperate regions in Australia have met with little success. Lolicato (1997) evaluated a large number of perennial legume species but found nothing to match the persistence of *M. sativa* subsp. *sativa*. Li et al. (2008) evaluating 47 species of perennial legumes and herbs in a range of mixed farming zones across southern Australia also found no perennial legume to match the overall persistence of *M. sativa* subsp. *sativa*.

The objective of this study was to evaluate the persistence and production of a range of perennial forage legume species collected from environments similar to the target area, with the long term goal of providing producers in the target environment with well adapted alternative perennial pasture legume cultivars.

This paper reports on the persistence of the lines evaluated after 5 years.

Methods

After completion of an initial screening and characterisation program involving a large range of perennial legume lines, 7 commercial cultivars and 63 lines, representing the most promising material selected from 24 species representing 8 genera were sown into a randomised complete block design with 4 replications at two sites described in Table 1.

Table 1. Site details

Attribute	Jericho	Cressy
Latitude	42? 22’ 16.36” S	41? 43’ 57.76” S
Longitude	147? 18’ 57.19” E	147? 03’ 58.80” E
Elevation (m)	399	147
Mean annual rainfall (mm)	570	628
Mean maximum temperature (?C)	15.5	18.2
Mean minimum temperature (?C)	5.0	5.6
Soil texture	clay loam	sand
pH (water)	5.6	5.3
Colwell P mg/kg	9	46
Colwell K mg/kg	212	188

The lines evaluated were sourced from local and overseas genetic resource centres, the main centres being:

- USDA, Pullman, Washington, USA
- Margot Forde Germplasm Centre, New Zealand
- Department of Primary Industries Plant Materials Centre, Tasmania
- Australian Trifolium Genetic Resource Centre, Western Australia
- Australian Medicago Genetic Resource Centre, South Australia

All lines were sown as seed, with sowing rates ranging from 5 kg/ha to 50 kg/ha dependant on the seed size of the line. Seed was scarified and inoculated with the appropriate strains of rhizobium prior to sowing. The seed beds were prepared by rotary hoeing in August 2005. In September 2005 the lines were sown by mixing the seed with moistened sand and surface broadcasting by hand into 1m x 2m plots, covered by hand raking and rolled. Both sites received 300 kg/ha of 0-6-17 NPK prior to sowing, with a maintenance dressing of 200 kg/ha of 0-6-17 NPK applied in autumn 2007.

Seedling density counts were taken in two quadrats (0.25m x 0.25m), 4 weeks after sowing. Plant frequency (%) of each line was used as a measure of persistence. Assessments were taken after the autumn breaks of 2007 and 2010. A square quadrat of steel mesh with 100 cells (each 0.1m x 0.1m) was placed in a fixed position on the ground at each assessment time. For each plot, cells containing a portion of a live plant crown of the sown species were recorded and the total number of cells containing a live crown was used to estimate frequency of occurrence. Both sites were grazed on a rotational system to fit in with the collection of seasonal herbage production data (not reported in this paper).

Data from the Jericho and Cressy evaluation sites have been combined for presentation in this paper.

Results

Drought conditions prevailed at both sites for three of five years of the study. In 2006, 2007 and 2008 annual rainfall at the Jericho site was 56, 36 and 25 percent respectively, below the long term average and over the same period Cressy was 40, 30 and 20 percent respectively, below the long term average (Table 2).

Table 2. Rainfall data for the years 2005 to 2009

Year	Jericho		Cressy	
	Rainfall (mm)	Variation from the long term mean (%)	Rainfall (mm)	Variation from the long term mean (%)
2005	569	0	792	+26
2006	249	-56	379	-40
2007	366	-36	441	-30
2008	426	-25	500	-20
2009	687	+20	634	+1

For seedling density, all lines of *Astragalus chinensis*, *Trifolium africanum*, *Trifolium burchellianum* and *Trifolium medium* recorded low seedling numbers, resulting in poor swards with low plant densities at both sites. Germination and early establishment of the remaining lines resulted in good swards in the initial year at both sites. Results from frequency assessments confirmed the poor persistence of the three major *Trifolium* species *T. repens*, *T. pratense* and *T. fragiferum* in this environment with frequency percentages of 0, 7 and 3 respectively after 5 years (Table 3). The most notable feature in the data is the performance of the *M. sativa* subsp. sativa x *M. sativa* subsp. *falcata*, *T. ambiguum* and *T. tumens* lines, with the best lines of the species recording frequency percentages of 92, 55 and 65 respectively after five years.

Table 3. Species average and maximum establishment counts and frequency data taken from a combined site analysis

Species	Number of lines	2005 Seedling density (plants/m^2)		2007 Frequency (%)		2010 Frequency (%)	
		Mean	Highest	Mean	Highest	Mean	Highest
Astragalus chinensis	1	17	17	1	1	0	0
A. falcatus	1	135	135	15	15	3	3
*Coronilla varia**	8	46	104	13	26	10	16
Dorycnium hirsutum	1	180	180	8	8	1	1
Hedysarum coronarium	1	360	360	14	14	0	0
*Lotus corniculatus**	4	284	373	32	66	14	31
L. tenuis	1	388	388	58	58	1	1
*Medicago sativa**	1	138	138	64	64	60	60
M. sativa x falcata	2	298	316	86	87	91	92
Trifolium africanum	1	30	30	1	1	0	0
*T. ambiguum**	6	238	381	34	50	31	55
T. burchellianum	2	39	47	2	3	0	0

*T. fragiferum**	3	165	184	34	40	2	3
T. hybridum	2	318	344	12	20	0	0
T. medium	1	39	39	1	1	0	0
T. montanum	1	89	89	10	10	1	1
T. ochroleucum	3	290	342	34	39	21	28
T. pannonicum	2	260	271	4	5	1	1
T. physodes	10	194	339	21	47	14	33
*T. pratense**	7	303	377	36	41	4	7
*T. repens**	3	134	228	6	13	0	0
T. rubens	1	302	302	20	20	9	9
T. tumens	7	382	507	57	68	42	65
Vicia cracca	1	61	61	13	13	12	12
LSD (*P*=0.05)		61		12		10	

*****including a commercial cultivar

This is equal to or better than the *M. sativa* subsp. *sativa* control cv. Prime with a mean frequency percentage of 60. *Lotus corniculatus* persisted well at both sites up to 2007, however three years of drought at Jericho resulted in the species suffering a large decrease in plant numbers. *Lotus corniculatus* continued to persist at Cressy. Two other species worthy of further consideration are *Trifolium physodes* and *Trifolium ochroleucum*, recording frequency percentages of 33 and 28 respectively across the two sites after five years.

Conclusion

This study provides an assessment not only of the relative potential adaptation of the species tested to dryland pastures in cool temperate low to medium rainfall (500-750 mm) regions of Tasmania, but also in similar environments around the world. Since most of this study was conducted during moderate to severe drought conditions it may prove more relevant than if conditions had been wetter, as the changing climatic conditions indicate dryer conditions may now be the norm.

The adaptation shown by the lucerne hybrid *M. sativa subsp. sativa* x *M. sativa subsp. falcata*, *T. ambiguum* and *T. tumens* in this study, highlight the considerable potential these species have for dryland pastures across the target region.

Acknowledgements

The cooperation of the property owners in supplying land and assisting with grazing management of the sites is gratefully acknowledged. We also thank Gary Martin for his technical assistance during the life of this project.

References

Dear BS and Ewing MA (2008). The search for new pasture plants to achieve more sustainable production systems in southern Australia. Australian Journal of Experimental Agriculture 48, 387-396.

Dear BS, Moore GA and Hughes SJ (2003). Adaptation and potential contribution of temperate perennial legumes to the southern Australian wheatbelt: a review. Australian Journal of Experimental Agriculture 43, 1-18.

CSIRO (2009). Climate change projections and impacts on run off for Tasmania. CSIRO Tasmania sustainable yields project. www.clw.csiro.au/.../tassy/.../TasSY-2Climate-and-runoff-for-Tasmania.pdf. Accessed 1 June 2010.

Pook M (2001). Tasmania's Climate and Projections for the Century, Water Development Plan for Tasmania. www.dpiw.tas.gov.au/inter.nsf/Attachments/SSKA.../TasClimate.pdf. Accessed18 May 2010.

Lolicato SJ and Rogers ME (1997). Adaptation of pasture legumes to acid, shallow soils in central Victoria. Australian Journal of Experimental Agriculture 37, 779-91.

Li GD, Lodge GM, Moore GA, Craig AD, Dear BS, Boschma SP, Albertson TO, Miller SM, Harden S, Hayes RC, Hughes SJ, Snowball R, Smith AB and Cullis BC (2008). Evaluation of perennial pasture legumes and herbs to identify species with high herbage production and persistence in mixed farming zones in southern Australia. Australian Journal of Experimental Agriculture 48, 449-466.