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Herbaceous perennial legumes: new options for pasture in dryland livestock systems in sub-humid Mediterranean Chile

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Introduction

In a climate with winter-dominant rainfall and long dry summers, like in Central Chile, the introduction and use of annual legumes and grasses, to improve productivity of livestock farming systems and to the rehabilitation of degraded agroecosystems have been the main strategies in the last twenty years. Unfortunately, the growth rate of annual legumes is low during autumn and winter, and also plant senescence starts by the end of October due to low soil water availability. As a consequence, the distribution of biomass production is mainly concentrated in spring when temperatures are moderate and soil water is available. In other Mediterranean-type climates, particularly in Western and Southern Australia, research on perennial legumes has been a priority to increase the availability, quality and timing of forage production, and to tackle environmental problems such as salinization and erosion (Humphries *et al*., 2008). In this paper we present the first results of a new research line oriented to the introduction and assessment of perennial legumes with depth rooting systems in order to improve pasture productivity by extending the production period. The objectives were to introduce and evaluate the productivity and persistence of perennial forage legumes to summer drought in rainfed Mediterranean environments of Chile.

Materials and Methods

The field experiment was conducted at the Experimental Center of Cauquenes-INIA (35° 58’ S, 72° 17′ W; 140 m.a.s.l.), located in the interior dryland, of the sub-humid Mediterranean zone. The soil was a granitic classified as Ultic Palexeralfs. Soil pH (1:5 in water, 0–20 cm) was 7.0, the organic matter content was 1.6%. Long-term average annual precipitation is 695 mm, with a six-month (November to April) dry season.

Field experiments: Twenty genotypes from six perennial legume species were established in May 2012: nine cv of *Medicago sativa*, two *Hedysarum coronarium*, two *Bituminaria bituminosa*, one *Cullen australasicum*, three *Lotus tenuis*, and two *Lotus corniculatus* (Table 1). The experiment was evaluated till December 2014. Seedlings were grown in a glasshouse from seeds inoculated and lime pelleted with the appropriate strain of root nodule bacteria; *M. sativa* cultivars were inoculated with strain WSM2141, *Lotus* spp. with WSM166 and *Hedysarum coronarium* was inoculated with WSM1592. Plant survival (%) was assessed at the start of the second growing season (autumn) in order to determine the percentage of plants that survived the summer which had five months free of precipitation, by counting live plants in 3 m rows. Plant growth (height in cm) was evaluated at the end of the second winter (August) to measure growth and winter dormancy. Biomass was evaluated at the end of the growing season (December) in the first year of the experiment, and in September, November and January in the second and third seasons, by cutting the whole plot above 5 cm. Samples were oven-dried with forced air ventilation at 70°C until reaching a constant weight for dry matter (DM) determination.

Results and Discussion

Plant survival and winter growth:

A number of species, genus *Medicago*, *Psoralea* and *Cullen* experienced high survival rates (over 70%). On the contrary, cultivars of *Lotus tenuis, Lotus corniculatus, and Hedysarum coronarium*, did not persist properly. The low persistence of the latter two species could be due to failures in the persistence of rhizobia and therefore in the lack of nodulation (Fig. 1)

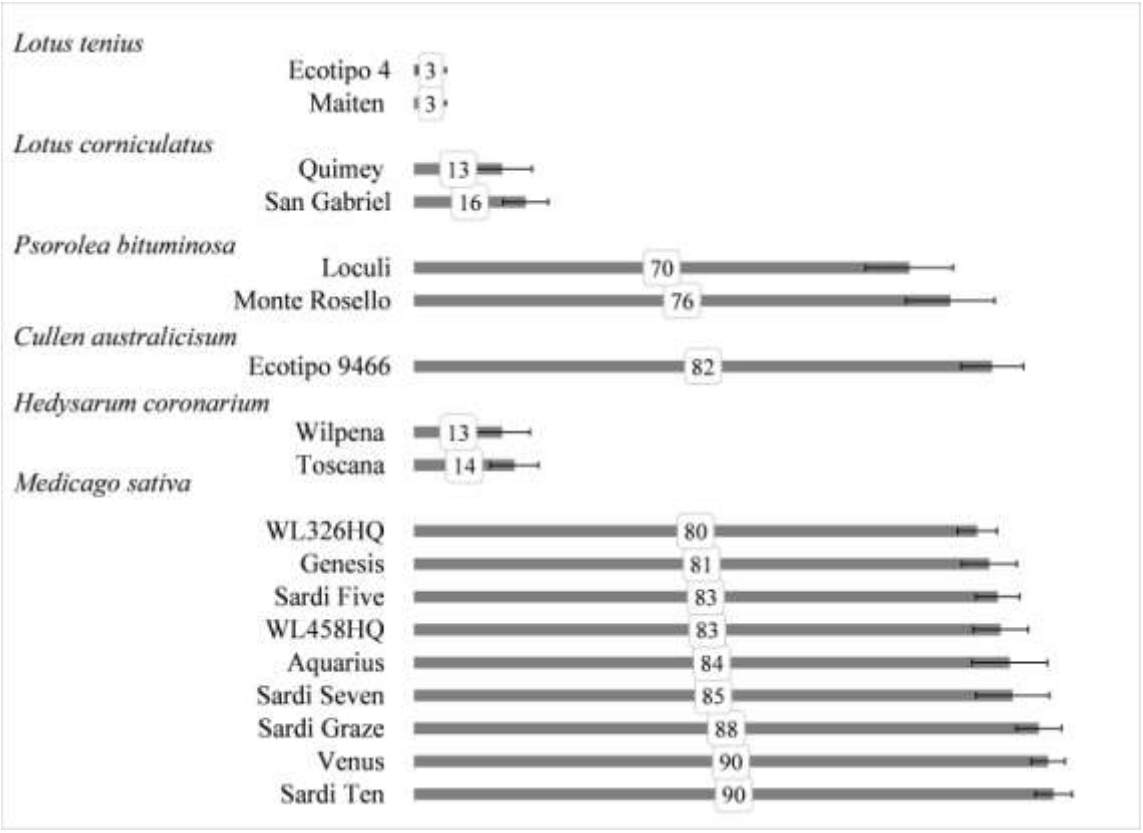

Fig. 1: Plant survival (%) of perennial legumes after three years of the establishment. The establishment density was 60 seedlings per plot (25 plants m^{-2}). LSD = 10.8.

Plant growths during the winter period differ among species and cultivars. Well known is the difference between Lotus spp. and *Medicago sativa*, however the low persistence and productivity of genotypes of Psoralea, Culen and *Hedysarum* do not allow valid comparison.

Biomass production: Among alfalfa cvs. large differences in total biomass production were not detected; a large group of cvs. exceeded 8000 kg DM ha-1, like Genesis, Sardi Ten, Sardi Seven, WL 903, Venus, and Aquarius . These levels of biomass production are superior to those obtained in dryland in South Australia by Humphries *et al.*, (2008). All other species of perennial legumes showed very low yields (Table 1).

Table 1: Plant height (cm) at the end of the winter period in 2013 and temporal distribution of the biomass production (kg DM ha^{-1}) from subsequent cutting or harvest of perennial legumes in three growing seasons (Experiment 1). Also winter activity class (WAC) for lucerne cultivars is included.

Species	Cultivar	WAC	Plant height	Biomass				Total	Biomass			Total
				28/12/12	19/08/13	08/11/13	7/01/14	2013-14	2/09/14	5/11/14	16/01/15	2014-15
Medicago sativa	Aquarius	8	37	1,560	2,092	4,071	1,638	7,800	2,599	6,474	1,945	11,018
	WL458HQ	6	29	1,750	1,265	3,471	1,826	6,562	1,875	5,807	1,565	9,247
	WL326HQ	4	22	1,383	893	3,426	1,758	6,077	1,502	5,046	1,615	8,163
	Venus	5	31	1,481	1,701	3,383	1,885	6,970	1,818	5,448	1,790	9,056
	Genesis	7	37	1,622	1,831	3,782	1,902	7,515	2,049	4,856	1,770	8,675
	SARDI Five	5	33	1,578	1,636	3,706	2,193	7,535	1,854	5,271	1,695	8,820
	SARDI Seven	7	36	1,813	1,833	3,822	1,923	7,579	2,025	4,797	1,500	8,321
	SARDI Ten	10	39	1,720	1,629	4,290	3,275	9,194	2,183	6,503	2,340	11,027
Hedysarum coronarium	Wilpena		24	1,188	2,102	513	0	2,615	1,761	--	--	1,761
	Toscana		30	1,203	2,686	441	0	3,126	2,52	--	--	2,520
Bituminaria bituminosa	Monte Rosello		2	--	--	--	--	--	--	--	--	--
	Loculi		2	--	--	--	--	--	--	--	--	--
Cullen australisicum	Ecotype SA 4966		2	--	--	--	--	--	--	--	--	--

Lotus tenuis	Maitén		11	1,176	304	406	0	710	--	--	--	--
	Ecotipo 4		11	630	248	100	0	348	--	--	--	--
Lotus corniculatus	San Gabriel		19	1,317	942	584	1,644	3,170	1,710	--	--	1,710
	Quimey		19	1,184	1,131	691	1,088	2,909	1,209	--	--	1,209
5% LSD				396	618	991	964	2,003	651	1,674	962	238
					0.54	0.82	0.63	0.88	0.39	0.31	0.37	0.39
Correlation with known winter activity class (lucerne only, r value)												

Winter production: In 2013, the Australian-origin cvs did not differ statistically in winter production (August evaluation), and their production ranged 1,629 - 2,092 kg DM ha-1 (Table 1); the Californian cvs WL326HQ and WL456HQ had lower winter growth compared to the Australian ones. However, in the third year (02 September 2014) no statistical differences were detected among lucerne cvs (Table 1). The production obtained at the end of winter is a resource of high value for a period in which the annual pasture virtually does not produce.

Summer production: SARDI Ten was significantly more productive (3,275 kg DM ha-1) than the other lucerne cvs, which did not differ in summer production. Cultivars San Gabriel and Quimey of *Lotus corniculatus* produced between 1,088 and 1,644 kg DM ha-1 (Table 1).

Conclusion

Several cv of alfalfa presented a high rate of survival of plants when they were establish under conditions of severe summer water stress prevailing in the interior dryland of the Mediterranean Sub-humid zone of Chile. On the contrary, the genotypes of the genus *Lotus, Hedysarum, Psoralea* and *Cullen,* did not persist in this environment.

Among alfalfa cvs, large differences in total production were not detected. A large group of cvs exceeded 8000 KgDMha-1. Among the most productive cvs: Genesis, Sardi ten, Sardi seven, WL 903, Venus, and Aquarius were highlighted.

Cultivars with low or no winter dormancy were most productive and appropriate for rainfed Mediterranean conditions of Chile.

Enhanced distribution of forage production could be obtained with low winter dormancy alfalfa cvs. Indeed, the most productive allow obtaining 2 ton MS in late winter, which is none achieved by any of the annual legumes options, currently used in the production systems. Finally, the production of late spring early summer, would prolong the period of animal grazing for about two months, compared to that achieved with annual legumes.

References

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