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Ten new annual legumes tested for unirrigated lands of the Mediterranean-climate region of Chile

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Summary - At the Cauquenes Experimental Center INIA, Chile (35°58'S 72°17'W), phenology, persistence, forage and seed production were evaluated in 10 annual legumes of potential economic and rehabilitation ecology value for the Mediterranean sub-humid zone of Chile. These included 7 cultivars (cvs.) of yellow and pink serradellas (*Ornithopus compressus* and *O. sativus*, respectively), 2 cvs. of biserrula (*Biserrula pelecinus*) and one cv. of balansa clover (*Trifolium michelianum*). The study period extended over three successive, climatically contrasted years, with annual rainfall ranging from 900 mm vs. 259 mm per year. The results will be directly incorporated in an existing selection and improvement program seeking the broadest possible spectrum of germoplasm in terms of timing of growth, winter vigour, seed size and dormancy characteristics of the various candidate species and cvs. The biserrula cv. Mor 99 showed high production potential and persistence in all three years of the study, despite being very late-flowering. The yellow serradella cvs. Eneabba, Paros, Santorini and Madeira were more precocious in their onset of flowering (by 7 to 15 days) than Pitman. Thus, this first group is apparently better adapted to the short spring conditions existing in the study area.

Key-words: annual forage legumes, Mediterranean pasture, interior drylands, *Ornithopus compressus*, *Biserrula pelecinus*

Résumé - La phénologie, la pérennité, la production de fourrage et de graines ont été évalués, à la station expérimentale de Cauquenes au Chili, sur 10 légumineuses annuelles à potentiel économique et écologique pour la zone subhumide du Chili. Les espèces étudiées comprennent 7 cultivars d'ornithope (*Ornithopus compressus* et *O. sativus*), 2 de biserrule (*Biserrula pelecinus*) et 1 de trèfle balance (*Trifolium michelianum*). Le suivi a été effectué pendant 3 années au climat contrasté avec des précipitations variant de 259 à 900 mm. Les meilleures variétés seront intégrées au programme de sélection et d'amélioration visant à constituer une banque de germoplasme la plus large possible en terme de période croissance, de vigueur hivernale, de taille des graines et de dormance. Le cultivar Mor99 de biserrule a présenté un fort potentiel productif et une bonne pérennité pendant les 3 années bien que sa floraison soit très tardive. Les cultivars d'ornithope Eneabba, Paros, Santorini et Madeira ont présenté une floraison plus précoce de 7 à 15 jours par rapport à Pitman. Ce groupe est donc mieux adapté aux conditions de printemps court propres à la zone d'étude.

Mots-clés: légumineuse annuelle, prairie méditerranéenne, zone sèche, *Ornithopus compressus*, *Biserrula pelecinus*

Introduction

The production and persistence of non-irrigated pastures in the Mediterranean climate region of central Chile is currently limited by the low diversity of valuable species and cultivars of annual forage legumes, especially those capable of producing appreciable quantities of biomass and self-renewal over many years in poorly drained soils, or those with low fertility, low pH, etc. Among those species and cultivars currently available, there is also a serious shortage of genetic variability in terms of agronomic traits of importance including size and "hardness" or dormancy of seeds, and vegetative and reproductive phenology permitting adaptation to zones with low annual rainfall and short, unpredictable periods of growth (Ovalle *et al.*, 1999). The

objective of this paper is to present comparative data phenology, dry matter and seed production in ten new species and cultivars of annual forage legumes recently introduced in Chile, and to discuss their eventual adaptation and utilization in the subhumid portion of the Mediterranean climate region of the country.

Materials and methods

The study was carried out in the subhumid Mediterranean climate, drylands area (*secano interior*), of south-central Chile (35°58'S 72°17'W, mean annual precipitation 695 mm, concentrated in the 7 coldest months of the year). Soils are predominantly a granitic loam, with low organic matter content and relatively acid soils (pH 6). The experimental material (Table 1) consisted of 7 species and 10 cultivars of annual legumes introduced from Australia thanks to an on-going collaboration between the Chilean INIA and CLIMA, in Perth, Australia. As "controls" we used the *Medicago polymorpha* cv. "Cauquenes-INIA" and the subterranean clovers cvs. "Clare" and "Seaton Park", all three of which are widely distributed in the overall study area. The experimental model consisted of a random-block design with four repetitions per species and cultivars. Each block was 2 x 6 m in size. Fertilization was applied annually and consisted of 90 kg P₂O₅ ha⁻¹, 50 kg K₂O ha⁻¹ and 20 kg boron calcite ha⁻¹. Mean annual rainfall at the site during the study was 986 mm, 229 mm and 541 mm for 1997, 1998 and 1999, respectively. This corresponds to "humid", "dry" and "normal" years, with respect to long-term rainfall data for the area.

The evaluations carried out concerned: a) Flowering phenology of the annual legume; b) Botanical composition of the plot (Daget and Poissonet, 1971); c) Dry matter production; d) Seed production (pod and naked seed) and e) Relative dormancy or "hard-seedness".

Results and discussion

Phenology

Considerable variability was observed in reproductive phenology (days to first flower) among the various species and cultivars evaluated (97 to 123 days). The cv. Cauquenes-INIA of *M. polymorpha*, was the most precocious (early-flowering), while *B. pelecinus* cv. Mor 99 was the last to flower. It is important to note that flowering time is among the most responsive or 'plastic' of all life history traits to variations in environmental conditions (Ehrman and Cocks 1996). Thus, precocious species are expected to be better adapted to the short spring conditions existing in unirrigated lands at Cauquenes and in the surrounding region. In this context, the Paros, Santorini and Enneaba cvs. of *O. compressus* appear especially promising, while the two cvs. of biserrula tested, and the Cadiz cv. of *O. sativus*, all appear to be too late-flowering for the conditions in our study area, especially in 'dry' years such as 1998.

Seed yield

In the 'humid' year of the study (1997), *B. pelecinus* and *M. polymorpha*, and the precocious sub-clover cv. Seaton Park and the *O. compressus* cv. Santorini, presented highest seed production (Fig. 1). However, it is interesting to compare whether the species in question also exhibit the capacity to produce seeds in a 'dry' year such as 1998. These data appear in the upper right-hand part of Fig. 1, and correspond to the precocious cvs. Cauquenes-INIA (*M. polymorpha*), Santorini (*O. compressus*) and Seaton Park (*T. subterraneum*). The cvs. of *B. pelecinus* tested, despite being much later flowering than those

just mentioned, both showed greater than average seed production in a 'dry' year; this result appears to be related to the relatively deep rooting patterns observed for this species.

Table 1. Days to flowering and seed characteristics in all species and cvs. evaluated.

Species	Cultivars	Days to flowering	Hard-seedness	Weight 1000 seeds (g)	N° seeds/gr
<i>M. polymorpha</i>	Cauquenes INIA	97	95.4	4.45	225
<i>T. subterraneum</i>	Seaton Park	101	39.1	7.0	136
<i>O. compressus</i>	Paros	106	99.6	2.48	403
<i>O. compressus</i>	Santorini	110	99.4	3.38	296
<i>O. compressus</i>	Eneabba	111	25.1	2.3	382
<i>O. compressus</i>	Madeira	112	98.9	1.78	563
<i>T. Brachycalycinum</i>	Clare	118	67.4	8.62	116
<i>T. Michelianum</i>	Paradana	118	96.1	0.93	1070
<i>O. sativus</i>	Cadiz	119	0.0	2.62	382
<i>O. compressus</i>	Pitman	120	93.2	3.4	483
<i>B. pelecinus</i>	Biserrula MOR96	123	100	0.88	1140
<i>O. compressus</i>	Tauro	123	33.6	2.5	398
<i>B. pelecinus</i>	Biserrula MOR99	124	99.9	0.87	1148

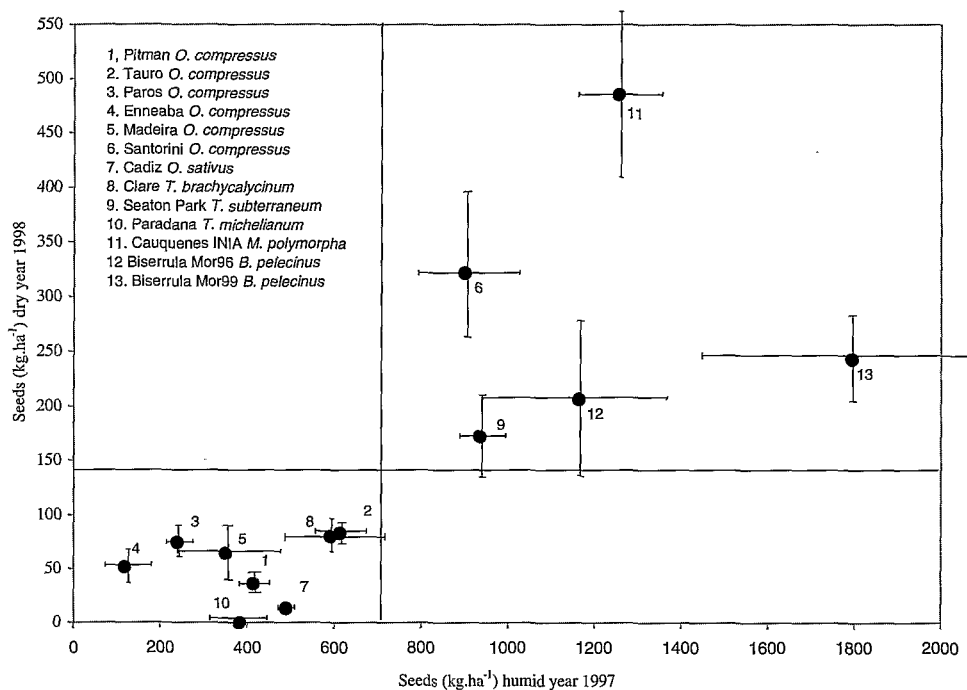


Figure 1. Annual seed yield of annual legumes pastures from 1997 - 1998.

Dry matter yield

Production levels for 1997 were apparently heavily influenced by the heavy rains occasioned by a strong "El Niño" effect occurring that year. Accordingly, dry matter production in several of the 'controls' and introductions tested surpassed 4 ton DM.ha⁻¹.yr⁻¹, e.g. in *O. sativus* cv. Cadiz, the Clare and Seaton Park sub-clovers, the biserrula Mor99, among others. This is an exceptionally high level of production for the study area. In the 1998

season, however (data not shown), a net decrease in production was observed, as a direct result of the severe drought conditions occurring that year. Taking the results for the three years of the study all together, a first group of species can be identified which showed high levels of production under the favorable conditions of the first year, but drastic decline in the succeeding years (species shown in, the lower right-hand portion of Fig. 2). A second group of species, which had also shown high production levels in 1997, and a decline in the 'dry' 1998, all showed a remarkable recovery in 1999 a 'normal' year, sometimes even exceeding their performance in 1997. This group includes all cvs. tested of *O. compressus* with the exception of cv. Tauro, and the two cvs. tested of *B. pelecinus*. Both these species are known to possess high levels of hard-seedness, which trait allows them to persist despite short-term 'accidents' like the unusually dry year of 1998.

The cv. Cadiz of *O. sativus* which does not possess 'hard' seeds (Table 1), and which showed very low seed production in the dry year 1998 (Fig. 2) also presented low persistence and seed production in the third year of the study. Especially interesting are the results obtained for the biserrula accession Mor 99, which showed high production potential in both 'humid' and 'dry' years of the study.

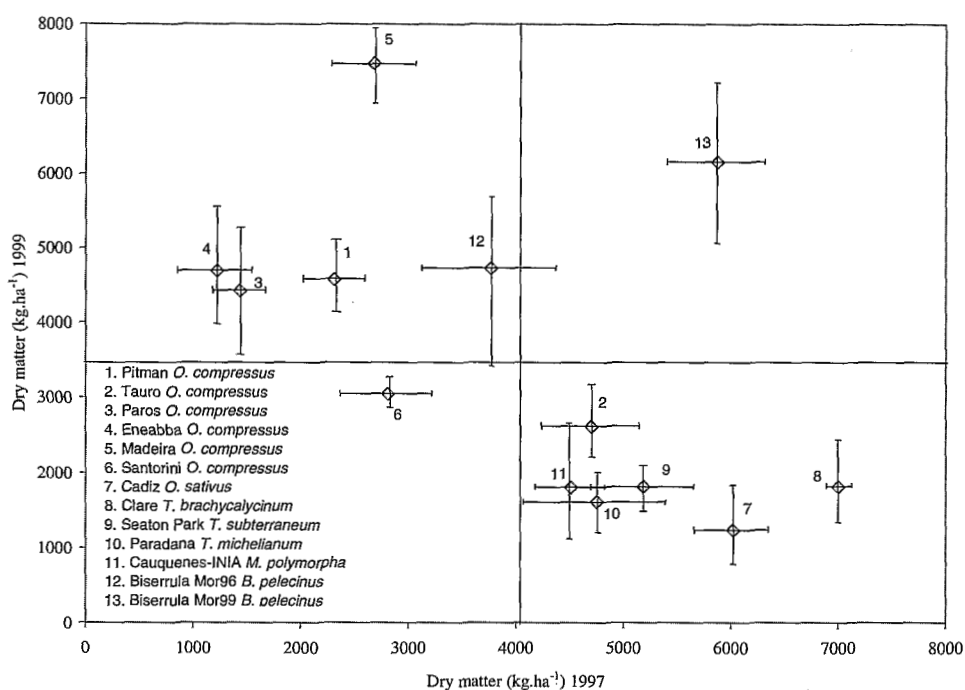


Figure 2. Annual dry matter yield (kg.DM.ha^{-1}) of annual legumes pastures from 1997 to 1999.

Conclusions

The extremely humid conditions of the first year (1997) dramatically influenced the behavior of the species and cvs. tested in the two succeeding years. In particular, an unusually large seed bank was stored in the soil and this favored species with late phenology. Despite this partial bias to the results, the results of this species and cv. evaluation will permit diversification and improvement of the annual forage legume germoplasm available for use in the "secano interior" of central Chile. Despite being later flowering than any of the annual legumes currently used in the study region, cv. Mor 99 of *B. pelecinus* showed the higher production potential of any accession tested. The cvs. Madeira, Pitman, Paros and Eneabba of *O. compressus* also showed good results in terms of production potential. However, cv.

Pitman the least precious of the four cvs tested may suffer in persistence and productivity over the long run, and especially in dry years. The cv. Cauquenes-INIA (*M. polymorpha*) showed both high seed production potential and relative flowering precocity, which combination probably explains the widespread naturalization of this species in central Chile. Clearly, the experiment described should be continued and pursued for a minimum of five years so as to allow drawing definitive conclusions concerning each of the candidate species and cvs under consideration.

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