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Rehabilitation with annual pasture legume mixtures in different Mediterranean regions

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RESUME – *"Réhabilitation des parcours par des mélanges de légumineuses annuelles dans différentes régions méditerranéennes". Des nouveaux mélanges de plantes fourragères sont nécessaires pour réhabiliter les terres dégradées et améliorer la productivité des parcours méditerranéens afin d'obtenir des pâturage persistants et de haute qualité. Huit mélanges de légumineuses annuelles avec un nombre croissant d'espèces (de 1 à 5) basé sur* Trifolium subterraneum sensu latu, Medicago polymorpha, T. michelianum, Ornithopus *spp. et* Biserrula pelecinus *ont été comparés dans une expérience de trois ans en Sardaigne (Italie) et à Cauquenes (Chili). Le trèfle souterrain participait pour 75% dans tous les mélanges. Après semis, la densité des plantes était plus élevée en Sardaigne qu'au Chili (400* vs *120 plants par m^2). La contribution de* T. michelianum, Ornithopus *spp. et* B. pelecinus *à la composition botanique et à la production fourragère était négligeable dans les deux régions, même quand ces espèces représentaient 25% du mélange, suggérant un manque de compétitivité face au trèfle souterrain. Au contraire, la contribution de* M. polymorpha *à la production de matière sèche totale surpasse les pourcentages initiaux de dose de semence (6,2-25%) et s'est étendue de 15 à 50% par rapport à sa contribution originale. La production de matière sèche, le rendement de semence et le resemis d'automne pour le trèfle souterrain et la luzerne annuelle ont été généralement plus élevés en Sardaigne qu'au Chili.*

Mots-clés : *Chili, Sardaigne, mélanges, légumineuses annuelles, production fourragère.*

Introduction

There is a general need of setting up new plant mixtures to rehabilitate degraded lands and to improve pasture productivity in the Mediterranean rainfed areas. The use of legume mixtures under sub-optimal and variable environmental conditions, like many agro-pastoral regions, could be essential to achieve persistent and high quality pasture swards. Because of their cool-season growth habit, high adaptation to summer drought through the ability to regenerate dense populations from year to year, and plasticity of response to seasonal fluctuations due to the buffering function of the seed reserves in the soil, the annual self-regenerating legumes are extraordinarily suited to Mediterranean-type climates (Piano and Talamucci, 1996). The use of annual legume mixtures, including new species and varieties recently released, could improve pasture quality and persistence. Moreover the lengthening of the grazing season seems more effective when different species of annual self-reseeding legumes such as subterranean clover and burr medic are combined in mixtures (Pardini *et al.*, 1996).

Materials and methods

Three-year (1998-2001) and two-year (1998-2000) experiments were carried out in Sardinia (Italy) and in Central Chile, respectively. The climate of the sites is typical Mediterranean with an average annual rainfall of 565 mm and 695 mm respectively. Soil types were alluvium sandy-loam with pH = 6.9 and granitic sandy-clay with pH = 5.8 respectively. Seven annual legume mixtures (MIX) were compared (Table 1).

The plots were sown in Autumn 1998 (12th June in Chile and 26th October in Sardinia) with a density of 500 viable and inoculated seeds per m^2. Fertilisation at sowing was 30 and 90 kg ha^{-1} of N and P_2O_5 in Sardinia and 100, 165, 90, 50 and 20 kg ha^{-1} of P_2O_5, CaO, S, K_2O and boron calcite, respectively, in Chile. In the latter, 50 kg ha^{-1} of P_2O_5 was also applied in the second year. The experimental design was a randomised block with four replicates and plots were 20 m^2 in area. Plots

were mowed when sward height reached 12 cm. The following data were collected: sward height, dry matter yield (DMY), percentage of legume species in the sward in spring and seed bank at the beginning of summer. Also the number of regenerating seedlings in autumn was recorded in Sardinia.

Table 1. Seeding rate (%) of the different mixtures in Sardinia and Chile

Species	MIX 0	MIX 1	MIX 2	MIX 3	MIX 4	MIX 5	MIX 6	MIX 7
Trifolium brachycalicinum cv Clare*	100	75	75	75	75	75	75	75
Medicago polymorpha cv Anglona /Cauquenes-INIA	-	25	-	-	-	12.5	8.3	6.2
T. michelianum cv Giorgia/Paradana	-	-	25	-	-	12.5	8.3	6.2
Ornitophus sativus cv Cadiz/ *O. compressus* cv Madeira	-	-	-	25	-	-	8.3	6.2
Biserrula pelecinus cv Casbah/Mor99	-	-	-	-	25	-	-	6.2

* In chile also *T. subterraneum* cv Seaton Park was utilized in the ratio 1:1.

Results and discussion

Total rainfall in Sardinia was below the average in the 1998-1999 (382 mm) and 1999-2000 (405 mm) seasons; it was unusually dry from January 2000 onwards and DMY was negatively affected. The season 2000-2001 was characterised by high autumn rainfalls while the spring was dry, with a total rainfall of 615 mm. In Chile, the first year was extremely dry (229 mm) and the second one was also below average (541 mm).

Seedling density at establishment of the different mixtures was higher in Sardinia (370-480 seedlings per m^2) than in Chile (100-130 seedlings per m^2). The MIX1 was more productive than MIX0 in the first year in both regions. Small or any significant differences were recorded in the two following years in Sardinia while MIX0 turned out to be less productive in Chile (Table 2). In the first year, only one utilisation to allow self-reseeding was done in both sites while two and four cuts were possible in the second and third year in Sardinia, respectively. Due to the severe spring drought just one utilisation was possible also in the second year in Chile.

Table 2. Dry matter yield (t ha^{-1}) of the different mixtures in Sardinia and Chile

	Sardinia			Chile	
Mixture	1st year	2nd year	3rd year	1st year	2nd year
MIX0	3.08	2.23	4.89	0.28	1.77
MIX1	4.26	2.41	4.57	0.66	2.31
MIX2	2.71	2.47	4.80	0.29	1.84
MIX3	2.44	2.50	4.57	0.27	2.63
MIX4	2.37	2.17	4.82	0.34	2.41
MIX5	3.12	2.21	4.37	0.54	2.33
MIX6	3.68	2.21	4.75	0.38	2.47
MIX7	2.81	2.48	4.76	0.42	3.02
LSD (P ≤ 0.05)	1.18	n.s.	0.30	0.16	1.30

The contribution of *T. michelianum* (Tm), *Ornithopus* spp. (Oc) and *B. pelecinus* (Bp) to the botanical composition and forage DMY was negligible (Sardinia) or very low (Chile) since the first year, even when these species represented 25% of the mixture seeding rate, suggesting a weak competitiveness with subterranean clover and also a low adaptation to the environmental conditions. On the contrary, the contribution of *M. polymorpha* (Mp) overpassed the percentages given by initial seeding rates in MIX1, MIX5 and MIX6. In Sardinia, burr medic showed high contribution during autumn and winter reaching up to 90% of total DMY. In the other mixtures, *T. subterraneum sensu latu* (Ts) represented on average the 90% of the total DMY showing to be very competitive also with native species (Fig. 1). A similar trend was observed in Chile where the contribution of other species was more important particularly in the second year (30-40%).

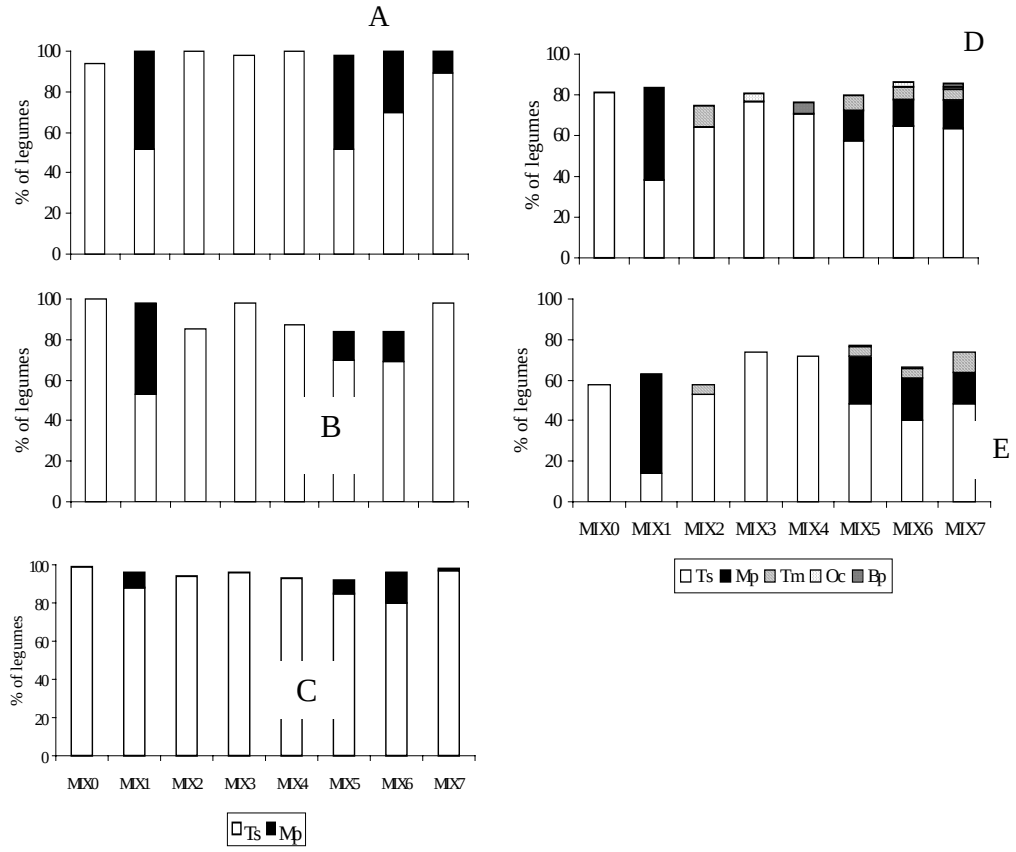

Fig. 1. legume species contribution: Sardinia, in 1999 (A), 2000 (B) and 2001(C); Chile, in 1998 (D) and 1999 (E).

The mixtures including burr medic showed significant higher level of soil seed bank in both sites during the first two years (Table 3). However the differences between mixtures tended to decrease in Sardinia in the third year due to an increasing predominance of subterranean clover.

Table 3. Soil seed bank of legumes (No. of seeds m^{-2} 10^3) in the two regions

	Sardinia			Chile	
Mixture	1st year	2nd year	3rd year	1st year	2nd year
MIX0	8.2	5.4	10.0	2.1	2.1
MIX1	50.6	26.5	14.5	8.2	32.8
MIX2	19.7	5.3	9.8	1.9	4.0
MIX3	10.0	5.6	11.2	2.5	6.1
MIX4	9.7	4.7	10.0	4.3	3.8
MIX5	30.6	18.2	14.3	5.9	18.5
MIX6	37.5	15.9	14.3	4.2	18.6
MIX7	16.5	5.7	11.8	4.6	15.0
LSD (P ≤ 0.05)	11.4	6.3	2.8	1.5	8.1

In Sardinia, the number of regenerating seedlings ranged on average from 2750 to 4900 / m^2 in autumn 2000 and 2001 respectively, with significant differences between mixtures. Higher seedlings densities were reached by the mixtures including *M. polymorpha* especially in the second year. The fast re-establishment and the great plant densities obtained with mixtures particularly those with *M. polymorpha*, guaranteed a high plant cover from early autumn, increasing soil protection against erosion.

The use of appropriate annual legume pasture mixtures appears to play a key role in improving

sward persistence and forage quality in addition to soil fertility, moreover stabilising *intra* and *inter* DM production. Subterranean clover was clearly favoured by sward management because spring cut removed part of burr medic flowers affecting negatively its self-reseeding. A reduction in the subterranean clover seeding rate and the use of legume species with similar prostrate habits and a restricted level of hard seeds could be suggested to achieve a more complex pasture sward.

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