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Introducing new grass-legume mixtures for pasture improvement in agro-pastoral farming systems

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SUMMARY – Several new annual legumes recently introduced in the Mediterranean market for pasture improvement were grown in mixture with grasses. Two new mixtures were formed to represent different levels of complexity (COMPLEX and SIMPLE) and were compared with a local mixture of oats and Italian ryegrass (AFC). The results collected in the two-year experiment did not show great differences regarding total dry matter production between the COMPLEX and SIMPLE mixtures. Many of the species included in the COMPLEX mixture did not perform adequately, showing a lack of persistence and adaptability to the soil conditions of the site. The experiment suggested that mixtures are important in pasture improvement, however preliminary studies on the ecology and adaptability of the species to the site are of paramount importance. Sowing simple mixtures of 4 or 5 species is probably the most cost-effective way for farmers to improve or establish a balanced mix pasture.

Keywords: Pasture improvement, grass-legume mixture, complexity.

RESUME – *"Introduction de nouveaux mélanges graminées-légumineuses pour l'amélioration des pâturages dans les systèmes d'exploitation agropastorale". Dans le but d'évaluer de nouvelles légumineuses annuelles récemment disponibles pour l'amélioration des pâturages dans la région méditerranéenne, en mélange avec des graminées, deux mélanges avec différents niveaux de complexité (COMPLEX et SIMPLE) ont été comparés à une culture fourragère annuelle (AFC), un mélange d'avoine et ray-grass d'Italie locaux. Après deux ans, les réponses quantitatives des deux mélanges ont été essentiellement non différentes. Beaucoup de nouvelles légumineuses annuelles composant le mélange COMPLEX n'ont pas montré une bonne capacité d'adaptation. L'expérience suggère que les mélanges sont importants dans l'amélioration des pâturages, mais les études préliminaires sur l'écologie et l'adaptabilité de l'espèce sur le site sont d'une importance fondamentale. Les semis de mélanges simples, de 4 ou 5 espèces, sont probablement le moyen le plus rentable pour les agriculteurs pour améliorer ou mettre en place un pâturage mixte équilibré.*

Mots-clés : *Amélioration des pâturages, mélange graminées-légumineuses, complexité.*

Introduction

In the Mediterranean regions, the climatic variability has a strong effect on the establishment and persistence of sown pastures. A study conducted by Crespo (1997) indicated that the diversification of the seed mixture could improve the chances of achieving a productive, balanced and persistent pasture. Encouraging results have been already obtained at a plot level by Porqueddu and Maltoni (2005) evaluating simple mixtures or in Western Australia at paddock scale (Wickham *et al*., 2007). This study was conducted at paddock scale to evaluate the introduction of pasture mixtures at a different level of complexity and investigate the potential adaptability of new species in the mix.

Materials and methods

The experiment was conducted from 2005 to 2007 and located in a private farm in Osilo (Sardinia-Italy) at 350 m a.s.l. with an average annual rainfall of 550 mm. The soil type was of calcareous origin, stony, with pH = 6.4 and with organic matter around 3%.

The paddock was divided in three strips (21.5 x 165 m), one for each treatment: (i) COMPLEX commercial pasture mixture, based on 26 varieties belonging to 15 species (Table 1); (ii) SIMPLE mixture, based on 5 species, including local cultivars and ecotypes and one commercial variety; and (iii) ANNUAL FORAGE CROP (AFC), based on a local mixture of oat and Italian ryegrass, managed conventionally, usually for direct utilisation in winter and hay production in late spring.

Table 1. Composition and sowing rate (kg ha^{-1}) of COMPLEX and SIMPLE pasture mixtures

COMPLEX mixture			
• Annual legumes		• Perennial grasses	
Biserrula pelecinus Casbah	1	*Dactylis glomerata* Currie	2
Medicago polymorpha Santiago, Scimitar	2	*Festuca arundinacea* Demeter	1
Ornithopus sativus Erica and Margurita	2	*Lolium perenne* Victorian	1
Trifolium glanduliferum Prima	1	*Phalaris aquatica* Atlas, Landmaster	2
Trifolium michelianum Paradana	2		
Trifolium resupinatum Prolific, Nitro Plus, Kyambro	3		
Trifolium subterraneum Dalkeith, Campeda	4	• Perennial legumes	
Trifolium subterraneum Clare, Davel	4	*Medicago sativa* Genesis, H. River	1
Trifolium subterraneum Trikkala, Riverina	2	*Lotus corniculatus* San Gabriel	0.5
Trifolium vesiculosum Cefalù	1	*Lotus tenuis* Estero	0.5
SIMPLE mixture			
• Annual grasses		• Perennial legumes	
Lolium rigidum Nurra	5	*Medicago sativa* Mamuntanas	8
• Annual legumes			
Medicago polymorpha Anglona	7	• Perennial grasses	
Trifolium subterraneum ec. Funtana Bona	2	*Dactylis glomerata Currie*	8

At the sowing, the fertilisation was made with 200 kg ha^{-1} of Diammonium Phosphate (18-46-0), for the AFC and 300 kg ha^{-1} of Phosphate (18% P_2O_5) for both mixtures. In the whole field, 15 kg ha^{-1} of Sulphate Fe (Fe SO_4) was also applied. The plots were sown on the14th October 2005, with 200 kg ha^{-1} of local seeds for AFC and at 30 kg ha^{-1} of seeds for the two mixtures. Seedling establishment was estimated at the 3rd trifoliate leaf for legumes, counting the number of seedlings on 20 quadrates (25 x 25 cm) per treatment. The field was grazed by "Sarda" bred dairy sheep, when the height of the canopy exceeded 15 cm. Before and after each grazing, biomass availability was estimated on 8 representative sample areas of 1 m^2 per treatment. The fresh biomass of each component was oven dried (80℃ for 48 hours) and weighted for estimati on of dry matter yield. Biomass production was also estimated at the end of spring on 4 ungrazed sample areas under fixed cages (1 x 1 m) per treatment.

Results and discussion

Rain distribution differed in the two years of the experiment. In 2005-06, the site experienced a very dry spring, with only 23 mm of rains set between April and June, while, in 2006-07, a good distribution of rains occurred, with about 100 mm of rain. Cold temperatures, with frost and snow, were recorded only for a brief period, at the end of March, in the second year.

Emergence

In the first year, as expected, the AFC emerged and established earlier than the two mixtures (Table 2). SIMPLE established better than COMPLEX. From the early phases, the native thistle (*Sylibum marianum* (L.) Gaertner) constituted slightly less than 10% of the botanical composition in the two mixtures. At the establishment, COMPLEX and SIMPLE mixtures had a similar composition in terms of sown grasses, while legumes species were better established in the SIMPLE mix.

In the second year, mixtures emerged at the same time of the AFC and the seedling density was significantly higher in the COMPLEX mix, with about 800 seedlings m^{-2}; since the early phases, n higher presence of *S. marianum* occurred, mainly in the COMPLEX mix paddock, occupying more than the 30% of the plot surface. Legumes in COMPLEX mixture seemed to establish sufficiently (40% of presence), while in SIMPLE a predominance of grasses (mainly due to annual ryegrass Nurra) was observed.

Table 2. Seedlings density and floristical composition in autumn. Values with the same letter do not differ significantly. Standard errors of the distribution of means for each treatment are reported between parethesis

	Seedlings density (nr. m^{-2})		Grasses (%)		Legumes (%)		Thistle (%)		Other spp. (%)	
Year	Ist	IInd	Ist	IInd	Ist	IInd	Ist	IInd	Ist	IInd
Treatment										
COMPLEX	319 *(30.9)*	828 *(134.2)*	38 *(3.5)*	10 *(1.6)*	47 *(3.4)*	40 *(4.4)*	9 *(1.5)*	32 *(4.3)*	6 *(3.1)*	18 *(4.1)*
SIMPLE	540 *(39.4)*	608 *(47.4)*	32 *(1.6)*	45 *(3.6)*	57 *(1.3)*	30 *(2.1)*	9 *(1.7)*	12 *(2.5)*	2 *(0.9)*	14 *(2.7)*
AFC	701 *(60.9)*	481 *(63.9)*	86 *(2.3)*	97 *(1.8)*			6 *(1.3)*	1 *(1.0)*	8 *(2.0)*	2 *(1.4)*

Biomass availability

In the first year, COMPLEX and SIMPLE mixtures were grazed only in spring, showing a slow growth rate (Table 3). More than 4 t ha^{-1} of available DM both for COMPLEX and SIMPLE were estimated. AFC produced an annual total of 3.8 t ha-1 of DM, being heavily grazed once in each season.

Table 3. Seasonal dry matter yield (DMY, t ha^{-1}) allowance (pre) and residual (post, in italic) for each seasonal grazing, and the annual DM in the ungrazed cages (U). Standard errors of the distribution of means for each treatment are reported between parenthesis

		Seasonal DMY							
		autumn		winter		spring		U	
Year		Ist	IInd	Ist	IInd	Ist	IInd	Ist	IInd
Treatment									
COMPLEX	pre		1.3 (0.08)		1.2 (0.13)*	4.1 (0.31)	1.3 (0.11)	3.3 (0.98)	8.1 (0.92)
	post		*0.9 (0.12)*			*3.1 (0.32)*	*0.7 (0.09)*		
SIMPLE	pre		1.3 (0.07)		1.0 (0.04)*	4.3 (0.26)	1.3 (0.07)	5.2 (0.20)	8.0 (0.58)
	post		*1.0 (0.10)*			*3.7 (0.39)*	*0.9 (0.09)*		
AFC	pre	1	0.9 (0.09)	1.2	0.3 (0.18)*	1.6 (0.15)	1.2 (0.13)	5.2 (0.75)	13.1 (0.34)
	post	--	*0.2 (0.07)*	--		*0.2 (0.01)*	*1.2 (0.11)*		

*Clearing cut (chopping) all over the experimental plots.

In the second year, the two mixtures were grazed simultaneously all over the year. The good autumn biomass production and the need to reduce the canopy height of the treatments to facilitate the Glyphosate herbicide distribution by direct contact on strongly colonizing thistle plants, lead to carry out an early grazing on SIMPLE and COMPLEX mixtures at mid November. A month after, a clearing of the canopy was carried out, it at 5-8 cm of height, trying to avoid damage to the re-growing grasses and legumes of the two mixtures. In early spring, a low grazing pressure was applied and the occurring of unexpected cold temperatures led to a very low consumption of the AFC canopy, which was left ungrazed for the further months.

In terms of undisturbed growth, a different response of the treatments to the inter-annual climatic variability was recorded: SIMPLE seemed to maintain a more balanced response to the different rainfalls trend in the two years, achieving respectively 5.2 and 8.1 t ha^{-1} of total ungrazed DM respectively in the first and second year. COMPLEX and AFC were evidently advantaged by the more regular rains distribution of the second year. Anyway, AFC showed the high level of total biomass production.

Floristic composition

In both years, the thistle maintained an average spring presence always higher than 30% in the two mixtures, probably due to the higher level of nitrogen fixed by the legume component. In the COMPLEX mix, *Lotus corniculatus, Ornithopus sativus* and *Festuca arundinacea* disappeared completely since the first year. In the second year, *Medicago sativa, T. michelianum, T. vesiculosum, T. glanduliferum, Biserrula pelecinus* and *Phalaris aquatica* were present only as isolated plants.

In the spring of the first year, in the ungrazed sward, the composition of COMPLEX was equally divided between legumes and other species, while the grasses were inconsistent. In particular, legumes were represented by burr medics (16%), gland clover (11%), subclovers, whether sown (4.5%) and spontaneous (10.4%), and Persian clovers (7.7%). In the second year, the COMPLEX response was clearly different with a predominance of subclovers and a positive adaptation of Victorian ryegrass to more humid conditions.

SIMPLE mixture, in ungrazed conditions, recorded an opposite adaptation response of annual ryegrass and subclover Funtana Bona in the two years; the ryegrass reduced its presence in the second year (-50%), while the local legume reacted to the well distributed rains reaching more than the 30% of in the total mixture.

Conclusions

After two years of experimentation, the quantitative responses of the mixtures at two different levels of complexity didn't differ substantially. Both mixtures gave competitive responses in terms of herbage allowance, compared with the annual forage crop, even suffering the disappearing or the scarce establishment of many components and the competition of the local flora. In the grass-legume mixtures, the competition against unsown species has been confirmed to be a challenge and a specific and appropriate weed control management should be applied.

Some of the new annual legumes included in the COMPLEX mixture have not performed adequately, probably due to low sowing rates and perhaps, in some cases, to lack of adaptation to the particular soil type. As an example, the *O. sativus* is not well adapted to calcareous soils with high level of free lime or biserrula generally doesn't survive in the first sowing year, under high competitive environment, particularly when low sowing rates are used.

The results clearly have shown the difficulty in establishing a balanced sward in Mediterranean environments. Detailed knowledge of the species is a desirable requirement for farmers and researchers, when making the mixtures to achieve optimal result. Simple mixtures with only 5-6 species are perhaps the best option to achieve successful establishment at minimum cost.

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