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The effects of P fertilization on spontaneous annual self-reseeding legume species of Mediterranean pastures

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Abstract. Natural and improved pastures represent an important component for forage systems, biodiversity, human activities, and rural countryside in Sardinia (Italy). However, research dealing with agronomic methods to increase the performances of spontaneous legumes in natural pastures, as an alternative to the introduction of the corresponding commercial varieties to improve pasture productivity, is still limited. A three-year trial was carried out to study the effects of phosphorus (P) fertilization in a natural pasture containing spontaneous legumes. Annual forage yields of grasses, legumes and others families and its quality and legume seed production have been monitored. Annual forage dry matter yield increased from 1 to 2 t ha^{-1} in P fertilized pasture compared to the unfertilized treatment. Legume contribution to the total DM yield increased from 4 to 40%. Moreover, forage quality and annual legume input to the soil seed bank significantly improved.

Keywords. Rangelands – Dry matter yield – Forage quality – Seed bank.

Les effets de la fertilisation phosphatée dans un pâturage naturel contenant des légumineuses spontanées

Résumé. *En Sardaigne (Italie) les pâturages naturels représentent un élément important non seulement comme source de fourrage, mais également en termes de biodiversité, ainsi que pour le maintien des activités humaines et du paysage rural. Cependant, les recherches qui concernent des méthodes agronomiques pour augmenter les performances des légumineuses spontanées dans les pâturages naturels restent encore limitées. Cela représente pourtant une alternative à l'introduction de variétés commerciales (pâturages semés) afin d'améliorer la productivité des pâturages. Un essai de trois ans a été réalisé pour étudier les effets de la fertilisation phosphatée dans un pâturage naturel contenant des légumineuses spontanées. La production fourragère annuelle (en quantité et qualité) des principaux groupes d'espèces (graminées, légumineuses et autres familles) ainsi que la production de semences de légumineuses ont été suivies. La production de matière sèche est passée de 1 à 2 t ha^{-1} dans les pâturages ayant reçu une fertilisation P par rapport au traitement non fertilisé. La contribution des légumineuses à la matière sèche totale est passée de 4 à 40%. En outre, la qualité du fourrage et la contribution de légumineuse annuelle à la banque de semences du sol a augmenté de façon significative.*

Mots-clés. *Pâturage – Production fourragère – Qualité du fourrage – Banque de semences.*

I – Introduction

Natural and improved pastures cover more than 1 million hectares in Sardinia, where they represent an important component, not only as forage source but also in terms of biodiversity, traditional human activities, and rural countryside. The low productivity of Sardinian rangelands is basically due to pedological and climatic factors (Bullitta *et al*., 1993), which impose short growth periods on the prevalent annual plant communities. Spontaneous self-reseeding legumes are an important biological element of Mediterranean pastures (Sulas, 2005). In fact, starting from germ-

plasm collections carried out in Mediterranean basin, several pasture and forage varieties have been released in Australia (Loi *et al.*, 2005) and widely used to improve pasture productivity. However, research dealing with agronomic methods to increase the performances of spontaneous legumes *in situ*, as an alternative to the introduction of the corresponding commercial varieties (sowed pastures), is still limited. On the other hand, low persistence and re-establishment have been recorded in 2nd generation legumes grown in Sardinia (Porqueddu *et al*., 2010). Chemical fertilization can be a cheap agronomic technique to improve pasture productivity and its quality (Bullitta *et al*., 1993; Martiniello and Berardo, 2007). In addition, chemical fertilization may affect the botanical composition of sward and the size and the type of seed bank of pasture species. We supposed that phosphorus (P) fertilization could maximize the performances of spontaneous annual self-reseeding legume species. This research aimed at studying the effects of the P fertilization of natural pastures containing spontaneous legumes in terms of annual forage yield, its quality and legume seed production, and in comparison with unfertilized pastures.

II – Materials and methods

A three-year trial was carried out during 2010-13 in Bolotana, Sardinia (Italy). The soil of the trial is shallow, waterlogged in winter and characterized by low fertility (Table 1). Within traditional agro-pastoral private farms, natural pasture areas were identified and plots were arranged in a randomized complete block design with three replicates. The size of each experimental unit was 50 m^2.

Table 1. Main pedo-climatic characteristics of the trial location (Bolotana, Nu)

Latitude/longitude	40°16'N / 8° 58'E	Assimilable P (mg kg^{-1})	3.5
Altitude (m.a.s.l.)	200	Exchangeable K (mg kg^{-1})	141.6
Sand/Silt/Clay (%)	68 / 12/ 20	Avg. rainfall	580
Soil series (Fao, 1988)	Eutric, Calcaric e Mollic Fluvisols	Avg. temperature (°C)	16.6
pH	6.3	Total rainfall 2011/12/'3	740/640/860

Each autumn, all plots were fertilized with 100 kg ha^{-1} of P_2O_5 using triple superphosphate. No additional fertilizer or herbicide was applied. At the end of each spring, dry matter (DM) yields for all plots were determined by cutting the aerial biomass at 5 cm above ground level on sampling areas, and by drying the cut material at 65 °C in a forced-air oven until a constant weight is obtained. Botanical composition was determined on subsamples by separating the main species groups: grasses, legumes and other dicotyledonous species. The dry biomass was ground finely for forage quality determination. Neutral, acid detergent fibre and lignin were determined according to Van Soest (1994). Crude protein (CP) was calculated by multiplying the N content (Kjeldahl method, 1965) by 6.25. In summer, legume seeds were taken from plots by digging up to 4 cm soil depth and legume seed bank size was determined. On collected data a one-way ANOVA was performed. Duncan test was applied to compare the treatments every year. Tests of significance were made at a 95% confidence level. Analyses were processed using SAS for Windows (SAS Institute, 1999).

III – Results and discussion

During the three years, annual rainfall exceeded the mean long-term value by 20%, on average. The total DM yield of the unfertilized natural pasture ranged from 0.7 to 1 t ha^{-1} (Fig. 1). The total DM production in the fertilized natural pasture was always higher than in unfertilized during the three years. In the third year, the total DM significantly decreased in the unfertilized plots. The botanical composition, as percentage of total DM, was almost stable but different between treatments. In the unfertilized pasture it was: 56% grasses, 4% legumes, 40% others species. In the fertilized pasture (43% grasses, 42% legumes, 15% others) the legume content was 10 times

higher compared to the unfertilized one. The most important legume species were: *Trifolium subterraneum, T. campestre, T. strictum, Medicago murex* and *Ornithopus compressus.*

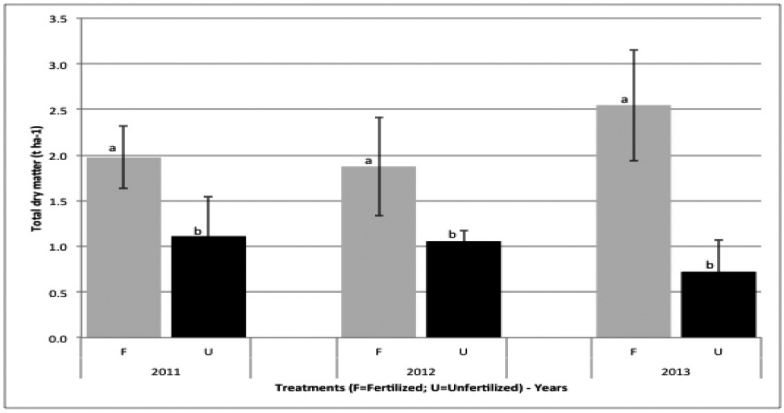

Fig. 1. Total dry matter (t ha^{-1}) in fertilized (F) and unfertilized (U) pastures (different letters within year indicate statistical differences at P<0.05).

The forage DM yields were representative of Mediterranean extensive pastures. The contribution of the native legumes remained very stable during the three years. On the contrary, a previous experiment in the same area pointed out that there was a remarkable presence of sowed commercial legume varieties in the sowing year only (Porqueddu *et al*., 2010).

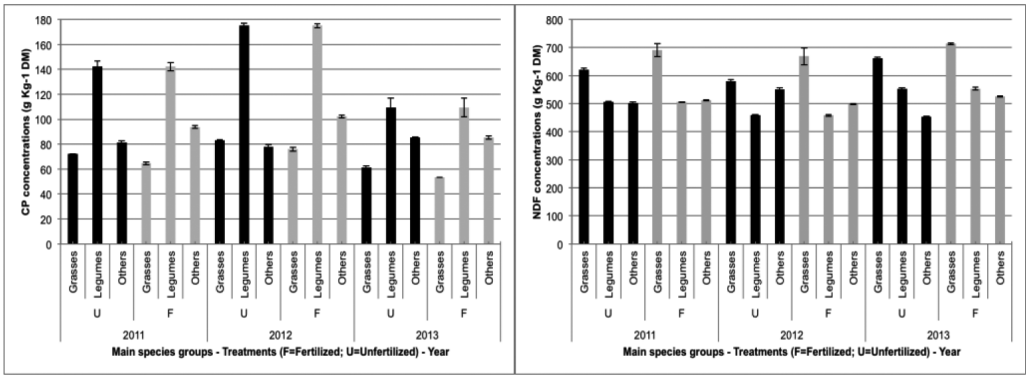

Fig. 2. Concentrations of a) crude protein b) neutral detergent fibre (NDF), in fertilized and unfertilized pastures.

The forage crude protein concentrations (Fig. 2a) ranged from 110 to 180 g kg^{-1} DM and was significantly higher in legumes. In fact, CP content never exceeded 80 and 100 g kg^{-1} DM in grasses and other species, respectively. The neutral detergent fibre concentration of grasses (Fig. 2b) showed higher values than legumes and other species (on average 700 *vs* 500 g kg^{-1} DM, in the fertilized pasture).

Total crude protein yields (Table 2) exceeded 200 kg ha^{-1} in the fertilized pasture. These contents were twice the unfertilized pasture, as a result of the concurrent remarkable legume contribution

and their high CP content in fertilized pasture. On the contrary, even if present, native legumes were not so effective in the unfertilized pasture. NDF yields ranged from 1,000 to more than 2,500 kg ha^{-1} in the fertilized pasture, and they were two to four times higher than those in the unfertilized one. Seed production was markedly affected by the different legume contribution recorded into pasture treatments. In the unfertilized pasture, legume seed yield ranged from 100 to about 700 seeds m^{-2}. In the fertilized pasture, it ranged from 6,000 to more than 10,000 seeds m^{-2} depending also on different single species contribution. Consequently, P fertilization strongly affected annual input to the legume soil seed bank.

Table 2. Total crude protein (CP) and neutral detergent fibre (NDF) in the main species groups

Treatments and species groups	CP (kg ha^{-1})			NDF (kg ha^{-1})		
	2011	2012	2013	2011	2012	2013
Fertilized-grasses	55.0	54.6	62.9	588.8	480.3	845.4
Fertilized-legumes	127.7	125.0	112.3	1862.3	327.7	568.4
Fertilized-others	17.6	45.4	28.7	96.1	220.7	176.4
Unfertilized-grasses	65.0	19.8	28.7	557.6	138.0	309.4
Unfertilized-others	13.5	61.9	17.6	83.3	437.4	93.1
Fertilized-Total	200.4a	224.9a	203.9a	2547.2a	1028.7a	1590.2a
Unfertilized-Total	78.5b	81.7b	46.3b	640.9b	575.5b	402.5b

Different letters within columns indicate statistical differences at P<0.05.

The native legume annual input to the seed bank was lower than that recorded in pure sward of commercial cultivar of pasture legumes (Salis *et al*., 2012) just in the year of sowing. Native legumes were able to guarantee an effective and remarkable contribution to the pasture production during all the three-year experiment.

IV – Conclusions

The three-year research point out that P fertilization has relevant effects on pasture productivity, forage quality and legume soil seed bank. Phosphorus fertilization can enhance the role of native legumes in rangelands and assure stable effects from year to year, contributing to improve the sustainability of the forage systems. Therefore, the exploitation of native pasture legumes should be carefully taken into account and regarded as a complementary option to the introduction of imported commercial varieties.

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