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to agriculture and environment

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## Organic farming in northeast of Portugal: effects of soil fertility management on DM yield and nutrients composition of pastures

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### Abstract

The aim of this work was to evaluate the effect of six types of soil fertility management: no fertiliser (NF), lime inputs (Ca), mineral fertilisation combined with liming (CaP (lime and phosphorous), CaPB (lime, phosphorous and boron), manure (M), and manure+lime+mineral fertilisation (MCApB), and two types of pasture (unsown and sown) on DM yield, botanical composition and nutrients content of pasture during two years of study. DM yield was significantly increased when plots were fertilised with manure (M and MCApB), which also improved the proportion of legumes, mainly in the sown pasture.

Keywords: pasture, organic and mineral fertilisation, grasses, legumes

### Introduction

The use of lime and fertilisers is one of the more extensively used agronomic practices to increase pasture productivity and to improve its nutritive value (Martiniello and Berardo, 2007). Both, lime and fertilisation introduce changes in the soil properties (pH, organic matter, available nutrients) that usually cause changes of pasture composition in a short period of time. The aim of this experiment was to study the effect of organic lime and manure fertilisation, combined or not with mineral fertilisation on DM yield, botanical composition and nutrients content.

### Material and methods

The experiment was carried out in Vila Meã, (NE Portugal; 860 m a.s.l.) on an acidic soil with an initial soil water pH around 4.5 (1:2.5). The experimental design was a hierarchical split-plot, where pasture type was the main plot and the soil fertility management treatments were the sub-plots. Two types of pasture were studied: spontaneous vegetation (unsown), and sown pasture (sown) with a mixture (kg ha<sup>-1</sup>): *Trifolium subterraneum* (2.6), *Trifolium vesiculosum* (1.3); *Trifolium michelianum* (0.6), *Trifolium incarnatum* (1.3), *Ornithopus sativus* (1.3); *Ornithopus compressus* (0.6); *Trifolium resupinatum* (0.6), *Biserula pelecinus* (0.6), *Trifolium repens* (0.6), *Trifolium fragiferum* (0.3), *Lolium perenne* (3.8), *Lolium multiflorum* (2.5), *Dactylis glomerata* (0.4), *Ph. Aquatica* (0.6), and *Cichorium intybus* (0.6). Soil fertility management treatments included: no fertiliser (NF), lime inputs (Ca), mineral fertilisation combined with liming (CaP (lime and phosphorous (P)), CaPB (lime, phosphorous and boron (B)), manure (M), and manure+lime+mineral fertilisation (MCApB). Manure and lime treatments implied inputs of 30 and 1.5 Mg ha<sup>-1</sup>, respectively. The inputs of phosphorous (P<sub>2</sub>O<sub>5</sub>; rock phosphate 26%) and boron (B; borax 15.2%) were of 100 and 1 kg ha<sup>-1</sup>, respectively. Finally, a control treatment without inputs was established (NF). In spring 2005 and 2007, three pasture samples were harvested inside enclosure cages on an area of 0.25 m<sup>2</sup> within each sub-plot. In spring 2006, no grazing was allowed in order to favour natural reseeding in sown and unsown pastures. The species were hand separated to determine botanical composition (grasses + other species (G+Ot) and legumes (Leg)). The samples were dried to constant weight (at 60 °C for 48 h) in order to determine dry matter content and pasture production and to perform chemical analyses. Total N and P were determined after a microKjeldahl digestion by colorimetry using TRAACS 800+ (Castro et al., 1990) and total Ca, Na, K and Mg were analysed with a VARIAN 220FS spectrophotometer using atomic absorption (VARIAN, 1989). Results were analysed by principal component analysis (PCA) based on a correlation matrix for the dependent variables, followed by ANOVA(s) on the PCA scores and original variables and mean separation (Tukey's HSD test).

## Results and Discussion

PCA was significant ( $P < 0.000$  – Bartlett's test of sphericity) in the explanation of dependent variables G+Ot and Leg, DM yield and nutrients composition of pastures (Figure 1). The first three PCA-axes explained 73% of the variation and were significantly influenced by pasture type and soil management treatment ( $P < 0.05$  – ANOVA(s) on the PCA scores). PCA1 was positively related to legumes percentage (Leg), DM yield and N, Ca and Mg levels, and negatively to G+Ot percentage, and CaPB soil fertility management treatments. PCA2 showed a positive relation with K, P and Mg levels, and negative with MCaPB treatment. Finally, PCA-3 was positively related to Na pasture levels and lime inputs (Ca), and negatively to M and MCaPB treatments and P pasture levels.

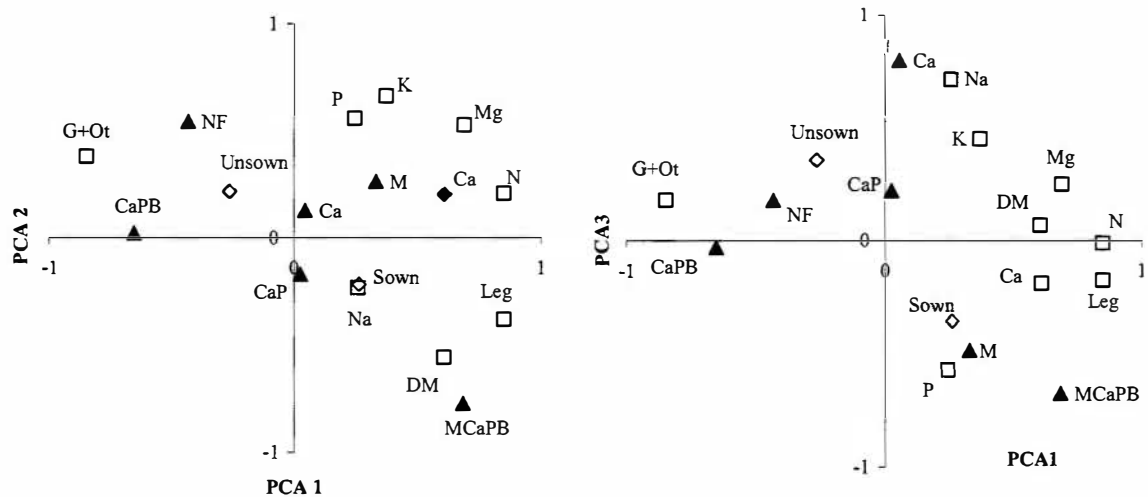


Figure 1. Loadings and scores of the first three PCAs, where: □: loadings of dependent variables (G+Ot: percentage of grasses and other species; Leg: percentage of legumes; DM: DM yield; nutrients levels: N, P, Ca, Na, K, and Mg); ∅: scores for pasture type (unsown and sown); ▲: scores for soil fertility management treatments (no fertiliser (NF), lime (Ca), manure (M), lime+phosphorous (CaP), lime+phosphorous+boron (CaPB), and manure+lime+mineral fertiliser (MCaPB)).

DM yield increased significantly during the second year (68% more in 2007 as compared to 2005) and on sown plots (24%) compared to unsown plots ( $p < 0.001$ ). It is known that grasses respond strongly to farmyard manure application and quickly invades areas with animal manure. However, when manure+lime+mineral fertilisation (MCaPB) was applied we observed a significant increase of DM yield and of the percentage of legumes (Figure 2). The same response was observed in 2007 when lime (Ca) or lime+phosphorous (CaP) were applied on sown plots. Brau-Nogue (1996) found that lime inputs quickly increases soil pH and soil nutrient availability, favouring a higher proportion of legumes (Spiegelberger *et al.* 2010) whose growth can be also enhanced by soil P fertilisation (Snyman, 2002).

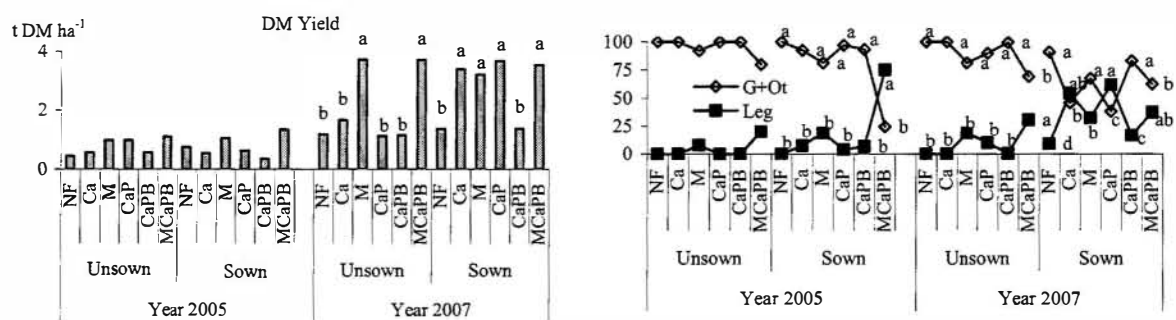


Figure 2. DM yield ( $t DM ha^{-1}$ ), percentage of grasses + other species (G+Ot) and legumes (Leg) in the two years of study (2005 and 2007), on the two types of pasture (unsown and sown) and in the six soil fertility management treatments. Different letters indicate significant differences between soil fertility management treatments in the same pasture type and in the same year ( $p < 0.01$ ).

The N, Mg and Ca content of the pasture tended to be higher in the MCaPB treatment (Table 1). This effect can be explained by the higher percentage of legumes, species that have higher concentrations of these nutrients than grasses (Thompson and Troeh, 1988). The percentage of P increased significantly in the treatments with manure (M and MCaPB) during the first year. Zhao *et al.* (2009) found that farmyard manure combined with mineral fertiliser increases soil available P compared to mineral fertiliser alone. Higher K content was obtained in Ca treatment compared to M, CaPB and MCaPB treatments. Finally, the levels of Na tended to be higher in the Ca treatment of unsown pasture. The obtained percentages of N, P, K, and Ca overcame cattle maintenance requirements; while those of Na and Mg were lower (NRC, 2000).

Table 1. Minerals contents for the two types of pasture (unsown and sown), and in the six soil fertility managements in the two years of the study (2005 and 2007). Different letters indicate significant differences between soil fertility management treatments in the same pasture type and in the same year ( $p < 0.01$ ).

	Unsown						Sown						
	NF	Ca	M	CaP	CaPB	MCaPB	NF	Ca	M	CaP	CaPB	MCaPB	
Year 2005	% N	1.04	1.13	1.09	1.00	1.20	1.29	1.03	1.11	1.21	1.13	0.98	1.68
	% P	0.12 <b>b</b>	0.13 <b>b</b>	0.27 <b>a</b>	0.14 <b>b</b>	0.14 <b>b</b>	0.22 <b>a</b>	0.24	0.20	0.25	0.19	0.20	0.23
	% K	1.38	1.34	1.14	1.06	1.15	1.19	0.96	0.81	1.16	0.68	0.72	0.91
	% Na	0.03	0.05	0.01	0.02	0.02	0.01	0.02	0.02	0.00	0.04	0.03	0.04
	% Mg	0.17	0.09	0.14	0.12	0.12	0.15	0.08	0.07	0.11	0.05	0.13	0.17
	% Ca	0.32	0.25	0.49	0.43	0.33	0.55	0.68	0.26	0.62	0.23	0.11	0.54
Year 2007	% N	0.86	0.87	1.28	1.06	1.03	1.20	1.33	1.62	1.19	1.59	1.07	1.09
	% P	0.17	0.16	0.17	0.20	0.18	0.15	0.17	0.16	0.17	0.16	0.19	0.14
	% K	0.93	0.95	1.00	1.09	1.15	0.65	1.08 <b>ab</b>	1.56 <b>a</b>	0.89 <b>b</b>	1.18 <b>ab</b>	0.82 <b>b</b>	0.68 <b>b</b>
	% Na	0.02	0.07	0.04	0.03	0.04	0.03	0.03	0.04	0.04	0.06	0.02	0.03
	% Mg	0.11	0.14	0.09	0.18	0.13	0.14	0.16	0.16	0.13	0.07	0.09	0.08
	% Ca	0.27	0.44	0.80	0.66	0.52	0.49	0.66	0.67	0.39	0.45	0.28	0.67

## Conclusions

Treatments with manure (M) or manure combined with lime and mineral fertilisation (MCaPB) showed the highest DM yields and legume percentage, mainly in sown pasture. Beyond the significant effect of manure+lime+mineral fertilisation (MCaPB) on DM yield and legume percentage, this treatment tended to have also higher N, P, Ca and Mg pasture levels.

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