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Contribution to the rehabilitation of pastures in degraded soils of the Southeast of Portugal

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RESUME – *"Contribution à la réhabilitation des pâturages en sols dégradés du sud-est du Portugal". On examine la production totale d'un pâturage semé et les concentrations foliaires de protéine, phosphore, potassium, calcium, magnésium et des métaux lourdes cuivre et zinc en deux années consécutives d'un essai de fertilisation mis en place sur un sol de la région de Mértola (Alentejo), avec une pente remarquable et un très bas niveau de fertilité. Le dessin expérimental était en quatre blocs casuels avec sept modalités: sans fertilisation, fertilisation minérale corrigée chaque année, trois niveaux (4, 8 et 12 t ha^{-1}) de fertilisation organique avec une boue d'épuration urbaine appliquée au début du premier an de l'essai et deux niveaux du même résidu (4 et 8 t ha^{-1}) appliqués aussi au premier an, mais complémentés avec de la fertilisation minérale au début de chaque cycle cultural. Le mélange des espèces semées était composé par* Trifolium subterraneum, Lollium rigidum *et* Ornithopus compressus*. Malgré que les légumineuses semées étaient en proportion insuffisant dans le matériel végétal obtenu au cours des deux cycles culturels, la production totale de matière sèche a augmenté avec l'application de boue (P ≤ 0,05), surtout au niveau le plus élevé. Au premier cycle cultural, la concentration foliaire de phosphore grandit aussi par application de 8 t ha^{-1} et 12 t ha^{-1} de boue. Les concentrations de cuivre et zinc du pâturage au niveau le plus haut de boue étaient inférieures au limite òu il faut craindre risque de toxicité par ces métaux pour les petits ruminants. Ces études seront poursuivies pour plus quelques années afin de pouvoir faire des recommandations plus pratiques au sujet de la valeur fertilisant de la boue vis-a-vis le pâturage, en évitant des risques de pollution du sol et le conséquent dommage pour les animaux.*

Mot-clés :*Boue d'épuration urbaine, pâturage, sol dégradé, agriculture durable.*

Introduction

Although the soils are thick and/or degraded in an appreciable area of the Alentejo region, they can have relevant production functions in extensive cattle breeding systems, if they are submitted to proper management practices, such as fertilisation, which also may improve their conservation. The environmental need of urban sewage sludge (USS) elimination in the EU countries may in part be satisfied by recycling this residue through the application in soils (Smith, 1996), namely those cropped with pasture. However, the national legislation should be followed, in particular the minimum timing between the sludge application and the grazing. In Portugal, the USS often has relatively high copper (Cu) and zinc (Zn) contents, which may limit its application rate to the soils. In this work, we examined the total dry matter yields and chemical composition (crude protein, P, K, Ca, Mg, Cu, and Zn foliar concentrations) of the pasture obtained in two successive growing seasons.

Materials and methods

A fertilisation experiment with sown pasture has been established in the autumn of 1997 on a poor Haplic Luvisol in Mértola with a slope of about 15% (PAMAF Project 4073). The experiment was a randomised block design, with seven treatments - no fertilisation, application of three rates of USS from Évora (4, 8 e 12 t/ha) in the first year, a yearly complemented mineral fertilisation, and the application of 4 and 8 t/ha of USS plus mineral fertilisation (P, K, and B) at the beginning of each growing season. The mixture of the sown species (29 kg/ha) consisted of subterranean clover (*Trifolium subterraneum* cv. Dalkeith, Seaton Park, Nungarin, and Daliak), annual ryegrass (*Lolium rigidum* cv. Wimmera), and bird's foot (*Ornithopus compressus* cv. Madeira and cv. Pittman).

Pasture fodder biomass was taken in two cuts (1st season) and one cut (2nd season). Plant tops concentrations were compared to the sheep requirements.

Results and discussion

Dry matter yield

Topsoil had a sandy loam texture and was slightly acid, with low amounts of organic matter, total nitrogen (N), nitrate and ammonium, available phosphorus, B, Cu, Mo, and Zn, which indicates deficiency of these nutrients for the normal growth of some arable crops.

The moisture content of the USS used in the experiment was low but the organic matter content was relatively high (438 g/kg). Among the elements present in the residue, N was dominant, followed by Ca and P. Copper was the heavy metal which concentration exceeded the limit (1000 mg/kg) allowed by the national legislation (Portaria 176/96). Zinc concentration was also remarkable (1400 mg/kg). Table 1 indicates the amounts of nutrients added to the soil through the fertilisers, at the beginning of each growing season.

Table 1. Amounts of elements applied to the soil in each treatment

Element	1997							1998		
	Treatments							Treatments		
	1	2	3	4	5	6	7	5	6	7
N (kg ha^{-1})	0.0	142.4	284.8	427.2	30.0	142.4	284.8	0.0	0.0	0.0
P (kg ha^{-1})	0.0	73.6	147.2	220.8	52.4	86.7	160.3	26.2	13.1	13.1
K (kg ha^{-1})	0.0	10.8	21.6	32.4	66.4	60.6	71.4	166.2	83.1	83.1
Ca (kg ha^{-1})	0.0	143.2	286.4	429.6	146.7	179.9	323.1	73.4	36.7	36.7
Mg (kg ha^{-1})	0.0	18.4	36.8	55.2	0.0	18.4	36.8	0.0	0.0	0.0
S (kg ha^{-1})	0.0	n.d.	n.d.	n.d.	84.3	20.0	20.0	0.0	0.0	0.0
Na (kg ha^{-1})	0.0	4.0	7.9	11.9	1.2	5.1	9.0	1.2	1.2	1.2
B (kg ha^{-1})	0.0	0.1	0.2	0.3	1.1	1.0	1.0	1.1	1.1	1.1
Cd (g ha^{-1})	0.0	6.2	12.5	25.0	0.0	6.2	12.5	0.0	0.0	0.0
Co (g ha^{-1})	0.0	18.8	37.5	62.5	75.0	93.8	118.8	0.0	0.0	0.0
Cr (kg ha^{-1})	0.0	0.3	0.7	1.0	0.0	0.3	0.7	0.0	0.0	0.0
Cu (kg ha^{-1})	0.0	9.0	18.1	27.1	1.3	9.0	18.1	0.0	0.0	0.0
Fe (kg ha^{-1})	0.0	70.4	140.8	211.2	0.0	70.4	140.0	0.0	0.0	0.0
Hg (g ha^{-1})	0.0	31.2	68.8	100.0	n.d.	31.2	68.8	0.0	0.0	0.0
Mn (kg ha^{-1})	0.0	2.6	5.2	7.7	0.0	2.6	5.2	0.0	0.0	0.0
Mo (g ha^{-1})	0.0	3.1	6.2	12.5	37.5	43.8	43.8	0.0	0.0	0.0
Ni (kg ha^{-1})	0.0	0.3	0.7	1.0	0.0	0.3	0.7	0.0	0.0	0.0
Pb (kg ha^{-1})	0.0	0.5	1.0	1.6	0.0	0.5	1.0	0.0	0.0	0.0
Zn (kg ha^{-1})	0.0	5.6	11.2	16.8	7.3	5.6	11.2	0.0	0.0	0.0

n.d. – not determined; 1: No fertilisation; 2: 4 t ha^{-1} USS rate; 3: 8 t ha^{-1} USS rate; 4: 12 t ha^{-1} USS rate; 5: Mineral fertilisation; 6: 4 t ha^{-}USS rate (1st year) + complement fertilisation; 7: 8 t ha^{-1} USS rate (1st year) + complement fertilisation.

The irregular precipitation along with both growing seasons (Table 2) greatly influenced the pasture production level (Fig. 1a) and the proportion of the sown species in the floristic composition of the pasture, which was low, especially as regard to the legumes.

In 1998, a trend towards higher dry matter yields at the highest USS rate was observed, but they did not differ from those observed at the "nil" treatment and at the 4 t/ha USS rate (1st year) plus complement fertilisation ($P \leq 0.05$). However, in 1999, although the yields were much lower than in 1998 due to abnormal weather dryness, the highest USS rate induced the significantly highest production increase. Higher amounts of the nutrients N, P, Cu, and Zn in available or mineralisable forms were added to the soil through this USS rate than by the complete mineral fertilisation (Table 1), which may explain the superiority of that treatment.

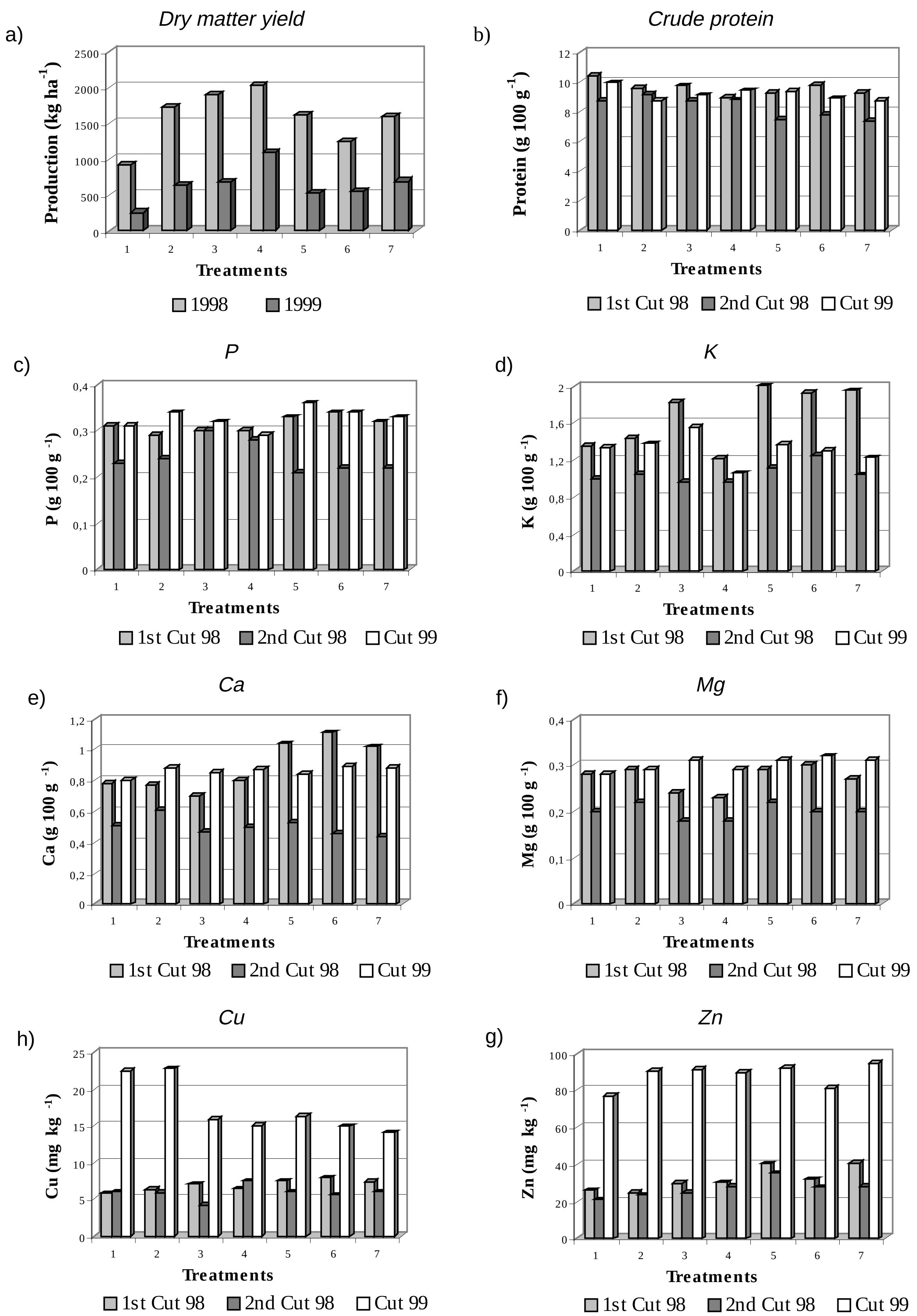

Fig. 1. Dry matter yield and concentrations of crude protein and some mineral elements in pasture: a) production; b) crude protein; c) total P; d) total K; e) total Ca; f) total Mg; g) total Cu; h) total Zn.

Table 2. Mean monthly precipitation between the pasture establishment and the end of the 2nd growing season

Month	1997	1998	1999
January	-	59.1	54.8
February	-	41.9	23.3
March	-	5.5	81.2
April	-	19.8	38.1
May	-	63.0	7.1
June	-	0.0	-
July	-	0.0	-
August	-	0.0	-
September	-	69.7	-
October	78.3	0.6	-
November	227.9	6.3	-
December	96.7	9.9	-

Chemical composition of the pasture

Most of the protein contents met the needs for sheep maintenance (> 9.4 g/100 g, 70 kg dry weight), according to the NRC (1985), excepting those observed at the 2nd harvest of 1998, in the middle of a dry spring. The application of USS did not induce significant variations in the crude protein content of the pasture biomass (Fig. 1b). Even so, at the 2nd harvest of 1998, protein content was higher at all the USS application rates than at the complete mineral fertiliser treatment.

At the 1st growing season (2nd cut), total P concentration increased with the 8 and 12 t/ha USS application rates (Fig. 1c). Potassium and Ca concentrations also increased (1st cut), especially in the treatments with mineral fertilisation corrected each year (Fig. 1d and Fig. 1e). However, the K concentrations were always enough to meet the mean sheep requirements (0.50-0.80 g/100 g), according to the NRC (1985). They also did not exceed 3 g/100 g, suggesting that the foliar K would not interfere with the Mg and Ca animal absorption. For lactating animals, the foliar P and Ca concentrations at the 2nd cut of 1998 were clearly deficient (lower than 0.38 g/100g and 0.82 g/100 g, respectively). The Mg concentrations (> 0.18 g/100g) surpassed the required needs for growing and beginning of lactation, even at the "nil" treatment. At the 2nd growing season, Cu and Zn pasture concentrations increased when they were compared to those of the 1st growing season (Fig. 1g and Fig. 1h), although they did not reach the maximum tolerable levels (25 mg/kg Cu and 750 mg/kg Zn) in the animal diet (NRC, 1985). The highest Cu and Zn contents (of about 22 mg/kg and 94 mg/kg, respectively) did not occur at the 12 t/ha USS application rate.

The proceeding of this study to evaluate the residual effects of the treatments, as well as for soil monitoring, is essential to conclude undoubtedly about the benefits of the USS in this soil to improve pasture yields and quality, with no risks of animal toxicity.

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