

# Meadows fertilized with compost, anaerobic and pelleted sewage sludge: effects on annual pasture production, botanical composition and alpha biodiversity

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## Abstract

Application of sewage sludge to agricultural soil is a common practice in the European Union (EU) because of low costs and recycling of nutrients achieved. The aim of this study was to evaluate the effects of different types (anaerobic, pelleted and composted sewage sludge) and application rates of sewage sludge on annual pasture production, botanical composition and species richness, compared with an unfertilized control treatment, in meadows established in Galicia (Spain). The results showed that annual pasture production was increased by anaerobic and pelleted sewage sludge in the first year of the study. However, no effects of treatments were found on botanical composition and species richness later in the study.

Keywords: biosolids, dose, sowing, waste, ryegrass, species richness

## Introduction

The EU promotes the use of sewage sludge as a fertilizer due to its specific organic matter and macronutrient contents, particularly nitrogen (MMA, 2006). The use of sewage sludge in agriculture includes several operations that improve efficiency of crop production, compared with mineral fertilizers, which are related to the stabilizing process before spreading. Anaerobic digestion and composting are two sewage sludge stabilization processes that are promoted by the EU (EEA, 2000) before the sludge is used as a fertilizer in agriculture. Pelletized sewage sludge is derived from the thermic treatment of anaerobic digested sewage sludge in order to reduce water content to 2%, which consequently reduces storage, transport and spreading costs compared with anaerobic or composted sludge (Mosquera-Losada *et al.*, 2010). The objective of the present study was to evaluate the effects of different types of sewage sludge (anaerobic, compost and pelleted) at different application rates (160 and 320 kg total N ha<sup>-1</sup>) compared with a control treatment (no fertilization) on annual pasture production, botanical composition and species richness in meadows established in the Atlantic bioclimatic region.

## Materials and methods

The experiment was established in Pol (Galicia, N.W. Spain; altitude 527 m a.s.l.) in spring 2003. The experimental design was a randomized complete block with three replicates and seven treatments. At the beginning of the experiment (March 2003) the soil was ploughed, and the pasture was sown with a mixture of *Lolium perenne* L. var. Brigantia (12.5 kg ha<sup>-1</sup>) and *Trifolium repens* L. var. Huia (4 kg ha<sup>-1</sup>). Fertilization treatments consisted of three types of sewage sludge: anaerobic (A), pelleted (P) and composted sewage sludge (C) applied at two different application rates (doses) in the first year of the study: 160 kg total N ha<sup>-1</sup> and 320 kg total N ha<sup>-1</sup>. No fertilization (0N) was used as a control. The calculation of the

required amounts of sludge was conducted according to the percentage of total nitrogen (EPA, 1994) and taking into account the Spanish regulation (R.D.1310/1990) regarding the heavy metal concentration for sewage sludge application. Plots (4×1.45 m) were harvested in June and December 2003, and in May, June and December 2004. The fresh forage was weighed in situ and a representative subsample was taken to the laboratory. At the laboratory, one pasture sample (95-100 g) was dried for 72 h at 60°C and weighed to estimate DM content and hence annual pasture DM production. The other sample (95-100 g) was separated by hand to determine botanical composition (percentage of grasses (%G), legumes (%L) and other species (%OT)). The different species were weighed separately to determine dry weight (72 h at 60°C) to estimate species richness (SR). Data were analysed by principal component analysis (PCA) based on a correlation matrix for the dependent variables (annual pasture production, botanical composition and SR). General linear models procedure (SAS, 2001) was used for ANOVA, and the difference among means was detected by LSD ( $P < 0.05$ ).

## Results and discussion

PCA was significant ( $P < 0.000$ ) in the explanation of dependent variables. The first three PCA-axes explained 89% of the variation. PCA1 (48% of total variability) was positively correlated with SR, %L, %OT and C<sub>160N</sub> treatment, and negatively with %G and A<sub>320N</sub> treatments (Figure 1). PCA2 (22% of total variability) was negatively related with %OT and A<sub>160N</sub> and positively related with %L and C<sub>320N</sub>. Finally, PCA3 (19% of total variability) was highly positively correlated with annual pasture production and A<sub>160N</sub>.

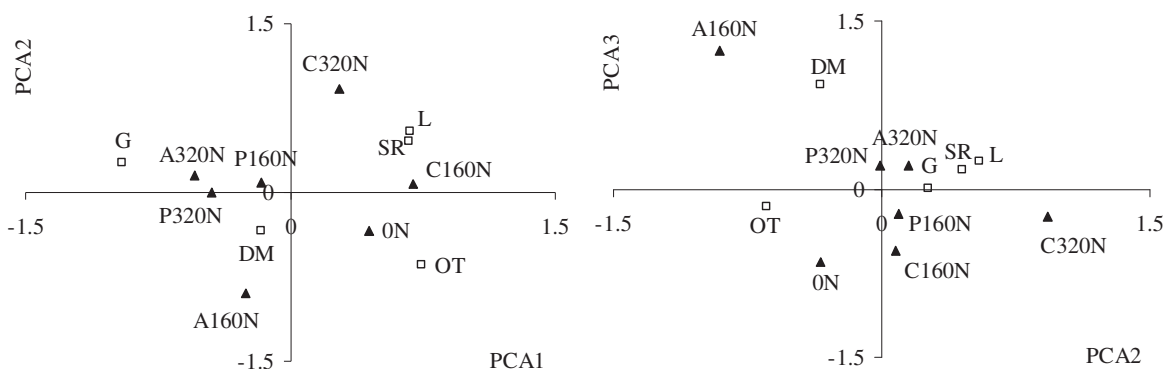


Figure 1. Loadings and scores of the first three PCAs and significant effect of fertilizer treatment ( $P < 0.05$ ), where: A, C, P: anaerobic, composted and pelleted sewage sludge, respectively; 0N: 0 kg total N ha<sup>-1</sup>, 160N: 160 kg total N ha<sup>-1</sup> and 320N: 320 kg total N ha<sup>-1</sup>; ◻: dependent variables (G, L, OT: percentage of grasses; legumes; and other species, respectively; DM: annual pasture production, and SR: species richness).

Pasture production levels were lower than that reported by Mosquera and González (1999) in Galicia (6-12 Mg DM ha<sup>-1</sup>) (Table 1). These lower levels could be explained by the fact that the study was established in a soil with low pH (4.9-5.3) and low effective exchange capacity (< 6 cmol (+) kg<sup>-1</sup>): conditions which usually indicate deficiencies in the availability of cations and, therefore, limit pasture production (Whitehead, 2000). In 2003, pasture production was significantly increased when anaerobic sludge (A<sub>160N</sub> and A<sub>320N</sub>) was applied with respect to no fertilization (0N), composted (C<sub>160N</sub> and C<sub>320N</sub>) and pelleted sludge at a high rate (P<sub>320N</sub>). Furthermore, P<sub>320N</sub> had a positive effect on pasture production with respect to no fertilization (0N) and composted sludge (C<sub>160N</sub> and C<sub>320N</sub>). The lower pasture production in composted sewage sludge was probably due to the lower mineralization rate and the N availability of this treatment compared with that of the other treatments (EPA, 1994). Annual pasture production was higher in 2004 than in 2003 due to higher and more favourably distributed rainfall in spring and summer of 2004 (data not shown). Significant differences

were not detected between treatments in pasture production in 2004 because there was no further residual effect of sewage sludge application. No effects of fertilizer treatments were found on botanical composition and SR (Table 1). However, in 2004 the percentage of legumes and other species increased in all treatments and contributed to increased SR.

Table 1. Pasture production (DM), botanical composition and species richness in 2003 and 2004. %G, %L, %OT: percentage of grasses, legumes and other species, respectively; A, C, P: anaerobic, compost and pelleted sewage sludge, respectively; 0-160-320N: 0, 160 and 320 kg total N ha<sup>-1</sup>, respectively. Different letters indicate significant differences between treatments ( $P < 0.001$ ).

Treatments	Year 2003					Year 2004				
	Mg DM ha <sup>-1</sup>	%G	%L	%OT	SR	Mg DM ha <sup>-1</sup>	%G	%L	%OT	SR
0N	1.09c	60.19	6.64	33.17	9	1.99	51.49	9.74	38.77	15
A160N	3.97a	84.30	0.13	15.57	7	3.73	51.33	9.87	38.80	13
C160N	0.87c	52.88	4.23	42.89	10	1.98	49.55	19.70	30.75	19
P160N	1.70bc	86.87	0.27	12.85	9	2.38	59.62	10.69	29.69	16
A320N	2.68ab	86.89	1.49	11.62	11	2.63	79.97	2.21	17.82	15
C320N	0.61c	86.91	0.47	12.62	10	2.39	45.65	33.92	20.44	17
P320N	2.45b	91.64	0.63	7.73	8	2.59	67.57	4.99	27.44	16

## Conclusions

Anaerobic and pelleted sewage sludge enhanced pasture production compared with compost sludge in the first year of application in meadows established in the Atlantic bioclimatic region. No residual effects of sewage sludge were found.

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