Sewage sludge fertilization effects on *Q. rubra* and pasture production and flora biodiversity

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Abstract

Fertilization is usually applied to increase land productivity, but this technique also affects biodiversity in silvopastoral systems. This study aims at evaluating the effect of different doses of sewage sludge on tree growth, pasture production and biodiversity during three years, at eight years after establishment of a silvopastoral system with *Quercus rubra.* Improving soil fertility increases grassland biodiversity until tree canopy cover is not complete.

Keywords: agroforestry, sowing, afforestation, anaerobic digestion, composting, pelletization

Introduction

Fertilization is usually applied to increase land productivity, but this technique also affects biodiversity in a spatial and temporal scale in grasslands. The introduction of a tree in a silvopastoral system also modifies biodiversity as it initially generates heterogeneity (unshaded and shaded areas) but later on, when tree canopy completely covers the understorey, a new homogeneous situation is created. Broadleaf trees are generally used in silvopastoral systems, *Quercus rubra* being of high interest due to its high timber quality and tree growth rate. The combination of trees and grassland is usually more efficient in the uptake of nutrients from soil, the tree being a good tool to use and recycle nutrients applied to the understorey with fertilizers. The use of sewage sludge as fertilizer has been promoted in the EU in recent years due to the high nutrient content. Tree development, as well as soil fertility improvement, could modify the relationship among the different understorey species. This study aims at evaluating the effect of different doses of sewage sludge on tree growth, pasture production and biodiversity during three years, at eight years after the establishment of a silvopastoral system with *Q. rubra*.

Materials and methods

The experiment was established in Baltar, A Pastoriza (Lugo, Galicia, northwest Spain) at an altitude of 475 m above sea level. Pasture was sown with a mixture of *Dactylis glomerata* L. var. Artabro (12.5 kg ha^{-1}), *Lolium perenne* L. var. Brigantia (12.5 kg ha^{-1}) and *Trifolium repens* L. var. Huia (4 kg ha^{-1}) in December 2004. Plants of *Q. rubra* Franco were planted at a density of 434 trees ha^{-1} after pasture sowing in 2001. The experimental design was a randomized complete block with three replicates and four treatments. Each experimental unit had an area of 368.64 m^2 and 25 trees planted with an arrangement of 5×5 stems with a distance between rows of 4.8 m, forming a perfect square. Treatments consisted of four doses of anaerobic sewage sludge meaning that 0, 100, 200 and 400 kg total N ha^{-1} were applied in 2001, 2002 and 2003. Sewage sludge was applied superficially and the calculation of the required amounts was conducted according to the percentage of total N and dry matter contents (EPA, 1994) and taking into account the Spanish regulation (R.D 1310/1990) (BOE, 1990) regarding heavy metal concentration for sewage sludge application. Tree heights were measured with a graduated ruler in October 2008 and pasture production was determined by taking four samples of pasture per plot at random (0.3 × 0.3 m^2) during the spring and winter from 2002 to 2008. In the laboratory, the pasture samples were dried (72 hours at 60ºC) and weighed to estimate dry matter production. Annual pasture production per year was calculated by summing the

consecutive harvests of the pasture production in that year. Before drying, the pasture samples were separated into the different species by hand. Data were analysed using ANOVA and differences between averages were shown by the LSD test, if ANOVA was significant. The statistical software package SAS (2001) was used for all analyses.

Results and discussion

Tree growth was significantly higher in treatments receiving 200 and 400 kg N total ha^{-1} than 0 or 100 kg N ha^{-1}. However, pasture production ha^{-1} was not modified during the three years, due to the lack of residual effect of fertilization. Higher doses of sewage sludge significantly increased pasture production in the first years of the experiment (Ferreiro-Domìnguez *et al*. 2011). Pasture production was reduced in the treatment with 200 kg N total ha^{-1}, probably explained because tree canopy cover was complete.

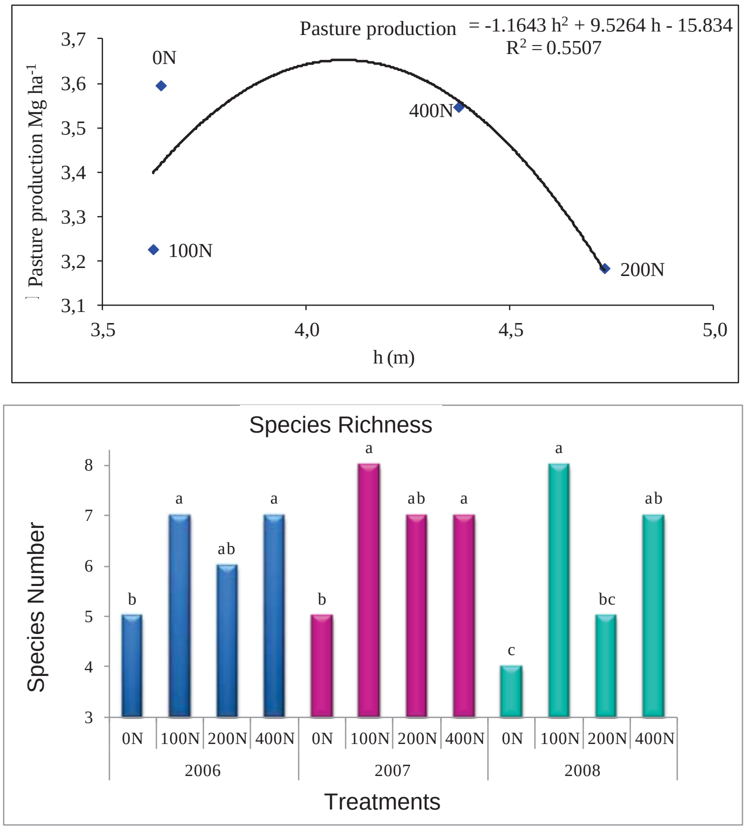

Figure 1. Tree height (m), annual pasture production (Mg ha^{-1}) relationship in 2008 is shown in the upper figure. Lower figure shows species richness per treatment Different letters indicate significant differences between treatments.

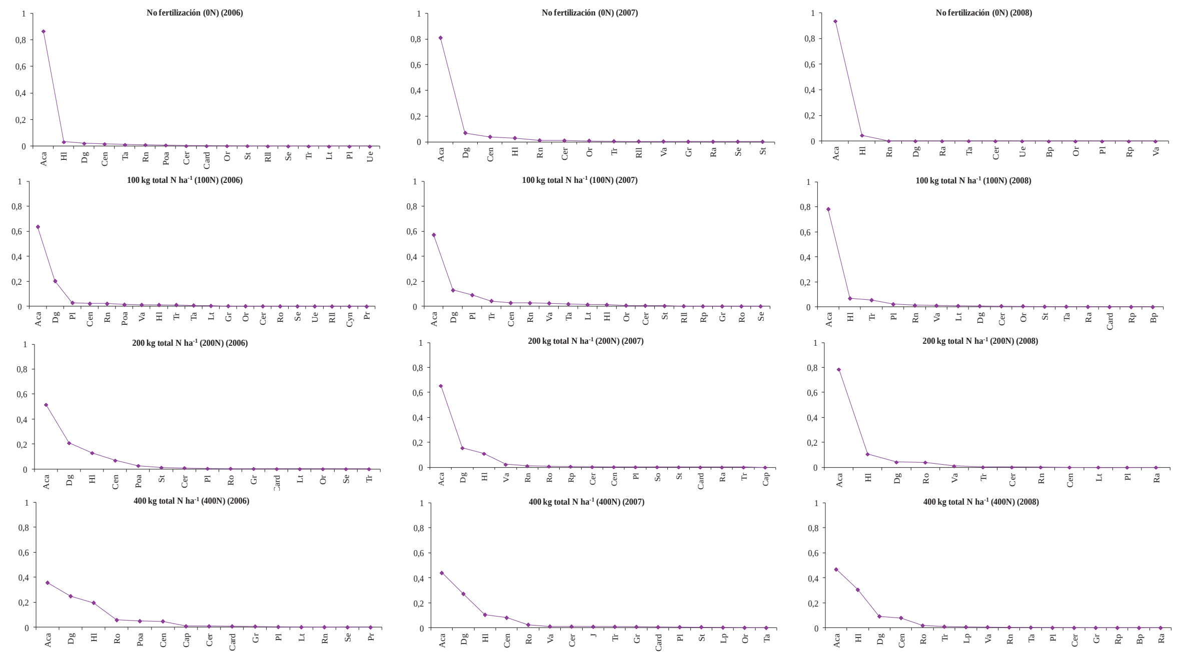

Figure 2. Abundance diagrams from 2006 to 2008 in the different treatments. Aca: *Agrostis capillaris* L., Bp: *Bellis perennis* L., Cap: *Capsella bursa pastoris* L., Card: *Cirsium arvense* L., Cen: *Centaurea limbata* Hoffmanns, Cer: *Cerastium glomeratum* Thuill, Cyn: *Cynosurus cristatus* L., Dg: *Dactylis glomerata* L., Gr: *Geranium rotundifolium* L., Hl: *Holcus lanatus* L., J: *Juncus effusus* L., Lp: *Lolium perenne* L., Lt: *Lotus corniculatus* L., Or: *Ornithopus compressus* L., Pl: *Plantago lanceolata* L., Poa: *Poa pratensis* L., Pr: *Prunella vulgaris* L., Ra: *Rumex acetosa* L., Rll: *Rumex acetosella* L., Rn: *Ranunculus repens* L., Ro: *Rumex obtusifolius* L., Rp: *Raphanus raphanistrum* L., Se: *Senecio jacobaea* L., St: *Stellaria media* L. (Vill), So: *Sonchus oleraceus* L., Ta: *Taraxacum officinale* Weber, Tr: *Trifolium repens* L, Ue: *Ulex europaeus* L., Va: *Veronica agrestis* L

Understorey species richness was promoted by fertilization from 2001 to 2008. The exception was the treatment with 200 kg N ha^{-1} in the last year, probably due to the lack of the heterogeneity created by the tree, which covers the understorey by a 100%.
The dominant species after 8 years of planting was *Agrostis capillaris*, which is usually adapted to soils with low fertility (treatments 0 and 100 kg N ha^{-1}) and shade (200 kg N ha^{-1}). However, this species is not dominant in the treatment with 400 kg N ha^{-1} due to the smaller amount of shade than in 200 kg N ha^{-1} and the advantage that high fertility provides the high dose of sewage sludge which promotes a co-dominance with species better adapted to higher soil fertility, like *Holcus lanatus* and *Dactylis glomerata*.

Conclusion

Improving soil fertility increases grassland biodiversity if tree canopy cover is not complete.

References

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