Grassland management options under Kyoto Protocol Article 3.4. The Portuguese case study

Valada T., Teixeira R., Martins H., Ribeiro M., Domingos T.

in

Acar Z. (ed.), López-Francos A. (ed.), Porqueddu C. (ed.).
New approaches for grassland research in a context of climate and socio-economic changes

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 102

2012
pages 53-56

Grassland management options under Kyoto Protocol Article 3.4

The Portuguese case study

T. Valada[1], R. Teixeira[2], H. Martins[3], M. Ribeiro[4] and T. Domingos[1]

[1]IN+ Center for Innovation, Technology and Policy Research, Environmental and Energy Scientific Area, Department of Mechanical Engineering (DEM), Instituto Superior Técnico, Technical University of Lisbon, Av. Rovisco Pais, 1, 1049-001 Lisbon (Portugal)
[2]Bluehorse Associates, Paris (France)
[3]Terraprima – Serviços Ambientais, Lda, Apartado 13048, E. C. Casal Ribeiro, 1000-000 Lisbon (Portugal)
[4]CERENA, Center for Natural Resources and the Environment, Instituto Superior Técnico, Technical University of Lisbon, Av. Rovisco Pais, 1, 1049-001 Lisbon (Portugal)
e-mail: tatiana.valada@ist.utl.pt

Abstract. Portugal has voluntarily committed to reporting the CO_2 emissions and removals resulting from grassland management under Kyoto Protocol Article 3.4. This commitment, together with the fact that a significant proportion of grasslands in Portugal are of low productivity and are located in the regions with higher risk of desertification, brought the context and motivation to promote the expansion of permanent sown biodiverse rich in legumes. These pastures are an innovation from the Biodiversity Engineering that promotes the increase of the soil organic matter and consequent carbon sequestration. Nowadays, this type of pasture represents more than 85 000 ha in Portugal, from which a significant percentage has been supported by the Portuguese Carbon Fund as a way of refunding farmers for the provision of an environmental service. Recently, the Portuguese Carbon Fund has also demonstrated interest in remunerating the farmers willing to control shrub encroachment at pastures through the use of non-invasive techniques that promote soil carbon sequestration. Regarding the biodiverse pastures, a 10 years model of the soil organic matter dynamic shows a carbon sequestration of about 6.5 t $CO_2.ha^{-1}.yr^{-1}$. In the case of the change of practice for shrub control, results from a preliminary model are promising in what concerns the prediction of carbon sequestration.

Keywords. Pastures – Non-tillage – Shrub control – Carbon sequestration – Land management.

Options de gestion de pâturages dans le contexte de l'article 3.4 du Protocole de Kyoto. Le cas d'étude de Portugal

Résumé. *Portugal est volontairement engagé à rendre compte du budget des émissions de CO_2 de la gestion des praires pour l'article 3.4 du Protocole de Kyoto. Cet engagement, en collaboration avec le fait qu'une proportion importante des pâturages au Portugal sont d'une faible productivité et sont situés dans les régions avec un risque plus élevé de la désertification, a introduit le contexte et la motivation de promouvoir l'expansion des pâturages biodiverses permanentes, riches en légumes. Ces pâturages, lorsqu'on les compare à celles naturelles, promeuvent l'augmentation de la matière organique du sol et la séquestration du carbone. Aujourd'hui, ce type de pâturage représente plus de 85 000 ha au Portugal, des quels une pourcentage importante est été financée par le Fond du Carbone Portugais. Ce Fond a également manifesté son intérêt pour rémunérer les agriculteurs qui acceptent de contrôler l'embroussaillement des pâturages avec l'utilisation de techniques non invasives et qui promeuvent la séquestration du carbone dans le sol. En ce qui concerne les pâturages biodiverses, le modèle de la dynamique de la matière organique du sol pendant 10 années montre une séquestration du carbone d'environ 6,5 t $CO_2.ha.^{-1}.an^{-1}$. Dans le cas du changement de la pratique pour le contrôle des arbustes, les résultats préliminaires sont promettants en ce qui concerne la prédiction de la séquestrationdu carbone.*

Mots-clés. *Pâturages – Non-travail du sol – Arbuste – Sequestration du carbone – Gestion des terres.*

I – Introduction

There are strict stipulations in the Kyoto Protocol (KP) as to how a country's emissions inventory is made, namely regarding what to account. However, there are some items that remain as an option for each signatory country. These options relate to the agro-forestry sector and are the so-called Land Use, Land Use Change and Forestry activities, now renamed Agriculture, Forestry and Other Land Uses (AFOLU), under the framework of Article 3.4 of the KP. While most sectors are net polluters, where all that can be done is to minimize CO_2 emissions, AFOLU activities are responsible for CO_2 sequestration in soils and living biomass. Therefore, AFOLU activities (IPCC, 2006) do not promote a decrease in emissions, but rather the sequestration of CO_2.

Portugal plays a leading role regarding AFOLU account in the KP, since it has decided to elect, in the framework of these voluntary AFOLU activities under Article 3.4 of the KP, the activities: "Grassland Management", "Cropland Management" and "Forest Management".

However, even using such additional measures as these, in 2006 PNAC still pointed to excess in emissions. A Portuguese Carbon Fund (PCF) was then created in order to fund and promote projects with innovative approaches to increase carbon sequestration through AFOLU activities.

Also of relevance, is the fact that historically, the most common type of pastures in Portugal are natural grasslands (NG) and fertilized natural grasslands (FNG). These are poor pastures, located in the regions with higher risk of desertification, with low productivity that support low stocking rates and require mechanical shrub control, with negative consequences regarding soil erosion. As an answer to these problems it is developed, around 1960, a new system of pastures – sown biodiverse permanent pastures rich in legumes (SBPPRL).

Within this context, Terraprima - Environmental Services, a spin-off enterprise from Instituto Superior Técnico, Technical University of Lisbon, submitted two projects related to grassland management to the Portuguese Carbon Fund that have been accepted. One regards the expansion of Sown Biodiverse Permanent Pastures rich in Legumes and the other the control of shrub encroachment at pastures through the use of non-invasive techniques. Both projects promote the increase in soil organic matter, and therefore, carbon sequestration. The sequestration of carbon is paid to farmers as an ecosystem services.

Sown biodiverse permanent pastures rich in legumes consist of diverse mixes of up to twenty different species or varieties of seeds, and are rich in legumes. Commonly SBPPRL are more productive than natural grasslands, and are also richer in number of species. There are fewer gaps in plant cover throughout the plots, since species variability ensures that the species more suited for each spatial condition will thrive. There are many studies on the role of biodiversity in productivity but SBPPRL remain the only widespread large-scale application of what may be called "biodiversity engineering".

The seed mix is designed specifically for each location after soil analysis. Species in the mix is adapted to soil physical and chemical characteristics, as well as to local climate conditions, and therefore there is no single representative mix. The higher plant productivity of SBPPRL implies increased atmospheric carbon capture through photosynthesis. Part of the biomass produced is stored in soils due to the high density of yearly-renewed roots.

If the pastures are well managed, as happens with the SBPPRL, there is no need for shrub control. However, that is not the case with the common natural pastures, fertilized or not. In these cases, there is the need to control, and the most used technique is the plow tillage. This technique causes enormous losses of soil organic carbon and N pools as greenhouse gases to the atmosphere (Blanco-Caqui and Lal, 2008). The plow tillage also decreases soil quality and increases the probability of erosion. Therefore, the change from tillage techniques to no tillage ones, presents as an important management change.

In this context, this work aims to quantify the carbon sequestration that takes place due to these management changes as well as its importance in the context of KP.

II – Method

For both projects, we are measuring the soil organic matter (SOM), but our ultimate goal is to estimate the carbon sequestration that takes place. The organic matter content is measured in percentage points, $g_{SOM}/100g_{soil}$. The average soil bulk density in Portuguese soils is 1.48 $g.cm^{-3}$, according to the Harmonized World Soil Database (HWSD; Fisher *et al*., 2008). A 1pp increase in SOM means that there is an increase of 0.0148 g $SOM.cm^{-3}$. Using the sampling depth, the SOM mass per unit may then be subsequently determined per unit area. In order to convert SOM to carbon, it is assumed that about 58% of SOM corresponds to soil organic carbon which is then converted to CO_2.

1. Sown biodiverse permanent pastures rich in legumes

As presented in Teixeira *et al*. (2011), and regarding the SBPPRL, data was obtained from rainfed pastures in eight farms in Portugal from 2001 to 2005. Plot areas ranged from 5 to 15 ha. Each plot's soil and landscape type was approximately homogeneous, in terms of soil and previous use. Samples were collected both from SBPPRL, NG and FNG.

The soil organic matter modelling considers a simple mass balance model, according to which the mass percent balance of SOM is the difference between input and mineralization. To determine the grassland system in which the increases in SOM was highest, the SOM increase was calculated in all systems starting from the same initial SOM (Teixeira *et al*., 2011).

The model is estimated using 78 observations and an Ordinary Least Squares approach.

2. Shrub encroachment

The soil samples were collected in 173 different plots each with 500 m^2, distributed by 24 farms and 10 municipalities of inland Portugal, and three soil types (derived from sandstone, schist and granite), for the year of 2011. We aimed to sample representative variability regarding climate, geology and cover. We collected samples in soils with tillage management and no-tillage.

Since, in this case, we do not have a time series, the analysis is done considering the year that the last tillage mobilization took place. We aim to understand if, for soils with current no tillage management the soil organic matter is significantly higher than for those subject to tillage control. We used an Ordinary Least Squares approach.

III – Results and discussion

1. Sown biodiverse permanent pastures rich in legumes

As shown in Fig.1, a 10 years model allows an increase in SOM of about 0.21 $pp.yr^{-1}$, equivalent to 1.78 t $C.ha^{-1}.yr^{-1}$ and to the sequestration of 6.5 tons of CO_2 per hectare per year. This increase is higher than for FNG and NG, 0.08 pp.yr-1, equivalent to 0.71 t $C.ha^{-1}.yr^{-1}$ (Teixeira *et al*., 2011).

Concerning the pastures sown in 2009 and 2010, there was a total of about 25,000 ha, 289 landowners and an additional 4 years carbon sequestration of about 475,000 t CO_2. The pastures sown in 2011 / 2012 are expected to sum up 30,000 ha, 500 landowners and an additional 4 years carbon sequestration of about 740,000 t CO_2.

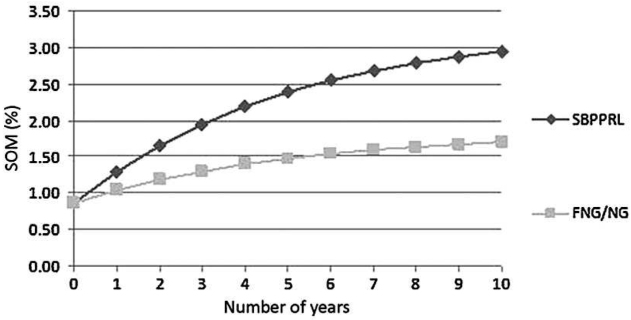

Fig. 1. 10 years model of SOM accumulation in SBPPRL, compared to FNG and NG.

2. Shrub encroachment

The results clearly indicate the presence of a higher content of organic matter in the samples associated with the no-tillage control. On average, for these samples, the organic matter is 1.1% higher. This implies a carbon sequestration of about 8.4 t $CO_2.ha^{-1}.yr^{-1}$. If the analysis is done by soil type, the carbon sequestration is about 11.2 t $CO_2.ha^{-1}.yr^{-1}$, for schist and 5.9 t $CO_2.ha^{-1}.yr^{-1}$, for sandstones. Due to the lack of representative data, it was not possible to calculate a factor for the soils derivative from granite.

In terms of field implementation, the aim is to extend this change of practices to 100,000 ha, contributing with 0.72 Mton CO_2.

IV – Conclusions

Both management changes allow an important carbon sequestration, which is accounted for in the KP and it is contributing to its fulfilment.

The sown biodiverse permanent pastures rich in legumes are currently highly implemented in Portugal, contributing, not only with carbon sequestration but also with a higher productivity and improvement of soil quality.

The change in control technique associated with shrub encroachment at pastures allows a soil carbon sequestration, associated with an increase in soil organic matter, and therefore, soil quality. This project is being currently implemented.

References

Blanco-Canqui H. and Lal R., 2008. No-tillage and soil profile carbon sequestration: An on-farm assessment. *Soil Sci. Soc. Am. J.*, (72), 3, 693-701.

Fisher G., Nachtergaele F., Prieler S., van Velthuizen H., Verelst L. and Wiberg D., 2008. Global Agro-ecological Zones Assessment for Agriculture. IIASA, Laxenburg, Austria and FAO, Rome.

Teixeira R., Domingos T., Costa A., Oliveira R., Farropas L., Calouro F., Barradas A. and Carneiro J. Soil organic matter dynamics in Portuguese natural and sown rainfed grasslands. In: *Ecological Modelling*, 222, 993-1001.