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Effect of Land Use Changes on Soil Erosion and Organic Carbon Pool in a Semiarid Area of Southeast Spain.

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Resume

La conversion de la forêt en cropland influence un certain nombre de propriétés de sol. Un des changements les plus prononcés et les plus répandus qui se produisent est le déclin dans le sol C, qui est attribué à un certain nombre de facteurs. En raison de l'importance sur le contenu de carbone de sol comme facteur principal dans les procédés d'érosion de sol dans des secteurs de semiarid, cette diminution du sol C avec le changement d'utilisation de la terre peut intensifier l'effet de l'érosion de l'eau et augmenter l'émission du CO2 à l'atmosphère avec une répercussion trás importante dans le changement global. Les résultats préliminaires d'une expérience pour évaluer l'impact du changement d'utilisation de la terre sur l'érosion et le carbone dynamiques sont présentés. Le changement d'utilisation de la terre de la forêt au cropland olive était une production de contrôle de sédiment de facteur important, et l'exportation de C. Thus sédiment-associé, dans la perte olive de sol de cropland étaient entre 2 et 7 fois plus haut que dans le secteur de forêt, selon l'événement. Ces valeurs sont équivalentes aux pertes érosion-induites du sédiment OC environ la chemise 6 plus haut à l'égard olive à la parcelle de terrain de forêt.

Abstract

Conversion of forest to cropland influences a number of soil properties. One of the most pronounced and widespread changes that occur is the decline in soil C, which is attributed to a number of factors. Due to the importance of soil carbon content as a key factor in the soil erosion processes in semiarid areas, the decrease in soil C with land use change can intensify the effect of water erosion and increase the emission of CO_2 to the atmosphere, with important repercussion in the global change. The preliminary results of an experiment to evaluate the impact of land use change on erosion and carbon dynamics are presented. Land use change from forest to olive cropland was an important factor controlling sediment production, and export of sediment-associated C. Thus, in the olive cropland soil loss were between 2 and 7 times higher than in the forest area, depending on the event. These values are equivalent to erosion-induced losses of sediment OC, those were about 6-fold higher in olive compared to the forest plot. A relationship between the amount of total OC lost in the sediments, and the concentration of total OC they contain seems to exist on the forest plot. On the olive plot this relationship is not so evident. On the contrary that occurred with the OC concentrations in the sediment that were similar in both soil uses, the concentration of DOC in runoff were between 2 and 4 times higher in the forest plot compared to the cultivated plot.

Introduction

Conversion of forest to cropland influences a number of soil properties. One of the most pronounced and widespread changes that occur is the decline in soil C, which is attributed to a number of factors. First, C inputs in agricultural systems are usually lower than those in native systems and, on the other hand, agricultural management practices may help to enhance decomposition by creating soil conditions that are more conducive to greater biological activity (Gregorich et al, 1998). Due to the importance on soil carbon content as a key factor in the soil erosion processes in semiarid areas, this decrease in soil C with land use change can intensify the effect of water erosion and increase the emission of CO_2 to the atmosphere, with important repercussion in the global change.

Since soil erosion by water is a selective process that preferentially removes those soil components having the smallest size and the lowest density (Lal, 1995) sediments are usually enriched in fine silt and clay-sized particles that contain the most stable C forms in soils (Golchin et al, 1998). Furthermore, a significant part of carbon removed from soils by erosive processes has been found to be dissolved in runoff water (Rodriguez Rodriguez et al, 2004).

Contradictory results in regard to destination of C moved from erosion to deposition points on the landscape, both as far as dissolved OC in runoff water and OC in sediments have been found in the literature (Hope, et al., 1994; Moore, 1998; Starr, et al., 2000).

The preliminary results of an experiment to evaluate the impact of land use change on erosion and carbon dynamics are presented. The specific objectives are: a) to assess the pool of total and mineralizable C in sediments from plots under different land use and 2) to determine the effect of land use and rainfall characteristics on the concentrations of labile C in runoff.

Materials and methods

The experimental area is located at Northeast of Murcia region in Southeast of Spain. The annual average precipitation is about 300 mm and the temperature, is relatively high, 16.6ºC leading to a high evapotranspiration rate (about 800 mm).

Three land uses have been selected: forest, olive cropland and a recovery natural area, which was cultivated with pasture about 15 years ago. The soil in the three study areas is a Petrocalcic Xerosol with high percentage of stones in the forest and natural recovering area. In each of these areas two erosion plots (8 meters large x 2 meters width) have been installed to measure soil erosion. A recording rain gauge measures the precipitation depth and the runoff and sediment are collected in a tank located at the bottom of the plot. After a runoff-producing storm, the tank content is thoroughly mixed and five aliquots were taken in acid-washed polypropylene one litre bottles with care being taken to include both dissolved and suspended material in sample. Runoff was dried in a forced air oven (65ºC) and the sediment weighted. Dried sediment was scrapped from beakers, ground, sieved (250µ) and stored for C analysis. Aliquot (~20 ml) of runoff sample was filtered through a Fisherbrand glass fiber filter (0.45 µ) and the filtrate used for dissolved organic C (DOC) determinations.

Sediment export was computed by multiplying sediment concentration (g sediment l^{-1}) and runoff volume (l). Carbon export during a rainfall event was computed as the product of soil loss (Kg soil loss ha^{-1}) and sediment C concentration ($gCkg^{-1}$).

Analysis of runoff filtrate for DOC was performed in a C analyser after treatment of the filtrate with H_3PO_4 to purge inorganic C. Finely ground (250µ) soil and sediment samples free of carbonates were analysed for total organic C by dry combustion procedure using a C-N analyser.

Bulk density was determined from undisturbed soil samples using a steel cylinder of 5 cm diameter and 5 cm height. Textural analysis from the soils and sediments was obtained using a laser device (Coulter LS 200) after removal of organic matter and chemical dispersion with hexametaphosphate.

Results and discussion

Plots soil properties

The soil organic carbon content in the forest area is next to three times higher compared to the cultivated one (26.9 g $K^{-1}$and 9.8 g K^{-1} for forest and cultivated, respectively). The loss of soil organic carbon content by the conversion of the forest into cultivated fields caused a higher BD in the cultivated soil (1.17 g cm^{-3} and 0.91 g cm^{-3} for cultivated and forest, respectively). A decline in soil aggregation in cultivated respect to the forest areas was also found (MWD: 1.64 mm and 1.78 mm for cultivated and forest, respectively). Other authors obtained similar results (Celik, 2005).

The soil texture is silt loam in both soil uses with 21.41% of clay, 65.88% of silt and 12.7% of sand in the forest area and slightly coarse texture, 23.53% of clay, 61.78% of silt and 14.68% of sand, in the cultivated area.

Rainfall and sediment export

Runoff and soil loss were always higher in the olive compared to the forest plot. The largest sediment-producing storm occurred the 15th of September with a soil loss in the olive plot seven times higher (127.88 g m^{-2}) than on the forest plot (17.55 g m^{-2}) (Table 1). The sediment concentration was, on the opposite, similar in both soil uses except for the highest event, where the olive plot sediment concentration was double (8.42 g l^{-1}) than in the forest plot (3.94. g l^{-1}). In general, as the rainfall depth increased a greater soil loss is observed on both soil uses.

Sediments were enriched in silt and clay-sized particles (enrichment ratio values greater than 1) and depleted in sand (enrichment ratio values lower than 1) in all the events and for the two soil uses. Greater enrichment ratios for the coarser particles were observed in those events with higher rainfall intensity.

Table 1. Events occurred in the study period

Date	Rainfall (mm)	I_{30} (mm h^{-1})	Runoff (%)		Sediment concentration (g l^{-1})		Soil loss (g m^{-2})	
			Natural	Olive	Forest	Olive	Forest	Olive
07/09/05	12	*	1.80	19.12	2.37	1.69	0.52	3.42
15/09/05	30	43	13.52	45.02	3.94	8.42	17.55	127.88
20/09/05	18.90	17.90	6.14	33.11	3.91	3.55	4.16	20.47
14/11/05	13.39	17.90	28.14	33.42	1.49	1.94	5.61	8.84

Carbon export on sediment and runoff

In table 2 can be seen the loss of total OC linked to the solid phase (sediments) and as DOC linked to the runoff water in the four events recorded. The content of the total OC of the sediments are similar between different soil uses and ranges between 15.91 and 11.85 gk^{-1} in the forest and 15.27 and 10.58 gk^{-1} in the cultivated area. Those are equivalent to erosion-induced losses of solid-phase OC between 0.006-0.277 g m^{-2} and 0.037-1.595 g m^{-2} for forest and cultivated area, respectively depending on the amount of sediments generated in each event (Tables1 and 2). The total OC lost by erosion in sediments is around 6 times higher in the cultivated compared to the forest plot. This result is consistent with the OC enrichment ratio values of the sediments observed whose are higher (close to unit) in the cultivated compared to the forest plot (Table 2). In the natural plot seems to exist a relationship between

the amount of total OC lost in the sediments, and the concentration of total OC they contain. In the olive plot this relations is not such as evident.
The concentration of DOC in runoff is between 2 and 4 times higher in the forest plot compared to the cultivated plot. This concentration varies in the different events ranging between 21.40 - 62.24 mgl^{-1} and 5.46-30.26 mgl^{-1} for forest and cultivated plot, respectively. This is equivalent to a total DOC in runoff between 0.01- 0.35 g m^{-2} and 0.025-0.45 g m^{-2} for forest and cultivate plot respectively depending on the runoff generated in each event and on its concentration. DOC accounts for 0.08-2.44% of the total values eroded in the natural plot and between 0.02-1.74% of the total eroded in the olive plots depending on the event. These values are similar to those accounted for the OC in the solid phase (sediment) whose range is between 1 and 1.50% in both soil uses.

Table 2. Eroded soil organic carbon in both soil uses.

	Date	Total OC sediments (gk^{-1})	OC enrichment ratio	Total OC sediments (g m^{-2})	DOC runoff (mg l^{-1})	DOC runoff (g m^{-2})
Forest	07/09/05	11.99	0.48	0.006	62.24	0.01
	15/09/05	15.91	0.64	0.277	42.28	0.35
	20/09/05	11.85	0.47	0.048	47.47	0.05
	14/11/05	*	*		21.40	0.08
Olive	07/09/05	10.58	0.83	0.037	26.5	0.059
	15/09/05	12.44	0.99	1.595	30.26	0.45
	20/09/05	15.27	1.21	0.31	29.63	0.016
	14/11/05	*	*	*	5.46	0.025

Conclusions

Soil loss on the olive cropland was between 2 and 7 times higher than in the forest area, depending on the event. These values were equivalent to erosion-induced losses of sediment OC about 6 times higher in olive respect to the forest plot. A relationship between the amount of total OC lost in the sediments, and the concentration of total OC they contain seems to exist on the forest plot. On the olive plot this relation is not so evident. On the contrary that occurred to the OC concentrations in the sediment that were similar between soil uses, the concentration of DOC in runoff were between 2 and 4 times higher in the forest plot compared to the cultivated plot.

References

Celik, I. 2005. Land use effect on organic matter and physical properties in soil on a southern Mediterranean highland of Turkey. Soil & Tillage Research, 83, 270-277.

Gregorich E.G., Greer, K.J., Anderson, D.W., Lang, B.C. 1998. Carbon distribution and losses: erosion and deposition effects. Soil Tillage Res. 47, 291-302

Moore, T. 1998. Disolved organic carbon: sources, sinks, and fluxes and role in the soil organic cycle. In: Lal, R., Kimble, J.M., Follet, R.F. (Eds). Soils processes and the carbon Cycle. Advances in Soil Science. CRC. Press, Boca Raton, FL, USA, pp. 281-292.

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Rodriguez Rodriguez, A., guerra, A., Arbelo, C., Mora, J.L., Gorrin, S.P., Armas, C. 2004. Forms eroded soil organic carbon in andosols of the Canary Islands (Spain). Geoderma 121, 205-219.

Starr, G.C., Lal, R., Malone, R., Hothem, D., Owens, L., Krimble, J. 2000. Modelling soil organic carbon transported by water erosion processes. Land Degrad. Dev. 11, 83-91.