Evaluation of soil erosion risk and identification of soil cover and management factor (C) for RUSLE in European vineyards with different soil management

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Abstract

Vineyards present some of the largest erosion rates reported in agricultural areas in Europe, although there is a large variability in reported rates. This is because under the same land use, erosional processes are highly affected by climate, soil, topography and by the adopted soil management practices (SMP). The choice of SMP to be adopted is the main way for farmers to control soil erosion and at the same time to increase other ecosystem services in vineyards.

The Revised Universal Soil Loss Equation (RUSLE) is commonly adopted to estimate rates of water erosion on cropland under different forms of land use and management. The identification of a proper value of the soil cover and management (C) factor is essential to obtain a reliable evaluation of soil erosion rates in a given area and for a specific land use. This paper presents the preliminary version of the analysis of erosion risk in vineyards, using ORUSCAL, which is a simplified erosion prediction model that is designed to calibrate RUSLE for a range of management conditions in vineyards with limited datasets. The analysis has been carried out in three wine-growing areas in Spain, Italy and Austria. The aim was to provide estimations of C-values and to explore the erosion risk under different SMP in wine-growing areas across Europe.

Keywords: vineyard, erosion, soil management, RUSLE, model, Italy, Spain, Austria.

Introduction, scope and main objectives

Vineyards represents one of the land uses for which very high rates of runoff and sediment losses has been observed in European agricultural areas (Cerdan *et al.*, 2010), although the reported erosion rates in vineyards across Europe present a large variability (Prosdocimi *et al.*, 2016). Under the same land use and similar conditions for climate, topography and soil texture, the soil management practice (SMP) adopted in the vineyard's inter-rows highly affects soil erosion risk in a given area. Moreover, soil management practices classified within the same category change in subtle but relevant details in different regions in Europe (Bauer et al., 2017). The choice of SMP to be adopted is the main way for farmers to control soil erosion and at the same time to increase other ecosystem services in vineyards (Winter *et al.*, 2018). Therefore, it is very important to provide to farmers and stakeholders a reliable evaluation of the erosion risk associated to the use of different SMP in order to support their choices, for instance by using soil erosion simulation models, such as the Revised Universal Soil Loss Equation (RUSLE) (Renard *et al.*, 2017), which is one of the most widely used and validated erosion tool (Dabney et al., 2012). Despite its relative simplicity, a proper RUSLE calibration is required for conditions outside of those widely covered in the USA.

This communication presents the preliminary results of the implementation of a simplified soil erosion prediction model in three wine-growing areas in Europe, and aimed to (i) identify values for the cover management factors and to (ii) evaluate soil erosion risk, considering the most adopted SMP.

Methodology

ORUSCAL is a simplified erosion prediction model based on RUSLE, which was designed and built as an Excel tool to allow the calibration of the Revised Universal Soil Loss Equation (RUSLE) for a broad range of management conditions in vineyards with limited datasets (Gómez *et al.*, 2016). In the ORUSCAL tool, each of the factors of RUSLE is calculated in one Excel sheet, or in several ones from each of the corresponding sub-factors. The model and different calibration strategies, for C and K parameters, were previously evaluated using a long-term experiment dataset (Biddoccu *et al.*, 2016) from a vineyard in Northern Italy (Gómez et al., 2017). In this study ORUSCAL was implemented in three regions: Spain (D.O. Montilla-Moriles), Italy (Monferrato area, Piedmont region), and Austria (Carnuntum and Leithaberg region) (Fig.1). ORUSCAL was fully calibrated for the D.O. Montilla-Moriles using 16 consecutive years: the C-factor for different soil management practices (SMP) was determined and its variability analysed as a preliminary evaluation of the approach to be implemented in other study areas. The topographic, soil, cover and management information required for calibration of ORUSCAL was taken from field survey in two of the study regions of the VineDivers project (www.vinedivers.eu). At each study region 16 vineyards were sampled. These vineyards were chosen to have 8 of the two most common soil management techniques in the region (low or high intensity in terms of encouraging ground cover in the alleys or not, respectively). Climate data were taken from nearby weather stations and rainfall erosivity (R factor) from Ballabio *et al.* (2016) to prevent bias in R determination across regions.

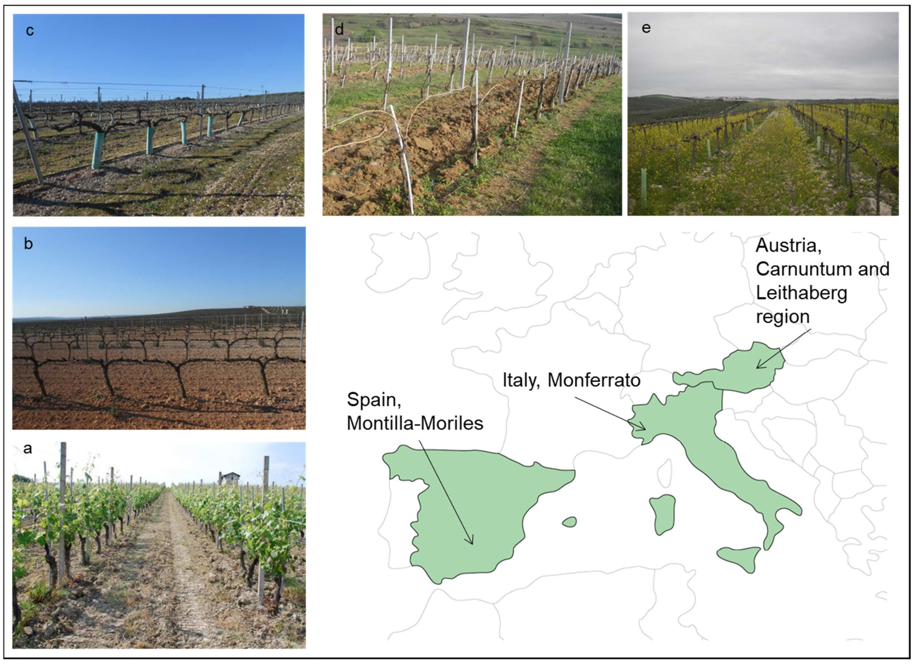

Fig. 1: Localization of the wine-growing study areas across Europe and examples of the considered SMP: a) and b) bare soil by tillage or herbicide (BS), c) and d) temporary cover crop (TCC), e) permanent cover crop (PCC).

Results

C-factor values were obtained as a result of the ORUSCAL calibration in the three areas, for vineyards with different cover and management practices (Table 1). Values obtained for bare soil (BS), obtained by tillage or herbicides, ranged from 0.17 to 0.27, representing for all location the worst condition in terms of soil protection. Temporary cover crop (TCC) was differently applied in Spain (ground cover only in fall and winter) and in Austria (vegetation cover every second lane, the other one tilled) and resulted in at least 48%

reduction of the C-factor values. The adoption of the lowest intensity soil management by using permanent vegetation cover (at least in the vineyard inter-rows) dramatically decreased the C-factor values that were lower than 0.04, thus not more than 15% of the C-value obtained for BS in the same area.
The soil erosion risk was evaluated in each area by means of the average annual soil loss (SL), calculated by ORUSCAL for the different SMP (Table 1). In Spain and Austria the TCC management resulted in 54% and 24% predicted SL, respectively, compared to vineyards managed with bare soil. In all study areas, the PCC management allowed a substantial reduction (more than 90%) of the predicted soil losses, with respect to the BS management.

Table 1: Results of the ORUSCAL implementation for the three study areas: C-factors obtained after calibration (C) and predicted annual average soil loss (SL, t ha^{-1} $year^{-1}$)

	Spain		Italy		Austria	
	C	SL	C	SL	C	SL
BS	0.27	17.5	0.17	8.5	0.27	19.4
std	0.03	14.8	0.05	6.3	-	12.4
TCC	0.13	9.5	-	-	0.14	4.7
std	0.07	4.5	-	-	-	2.8
PCC	0.04	1.6	0.01	0.6	0.04	1.4
std	0.00	1.4	0.01	0.4	-	0.8

Discussion

The determination of C-factor by means of proper calibration values for the three selected areas allows to obtain accurate values for different SMP currently adopted in European vineyards. The values seem to be relatively homogeneous across locations, and assume values spanning from 0.01 to 0.27, which are lower values than the general values indicated by Panagos et al. (2015) for European vineyards, ranging approximately from 0.15 to 0.45. The preliminary results of this study show the importance of performing RUSLE calibration, especially for the C-factor, when predicting soil losses for a land use as viticulture, in which erosion risk is highly affected by the adopted SMP. It also suggests the need for a further validation against long-term datasets at representative scales (e.g. Gómez *et al*., 2008). The application of the simplified model allowed the evaluation of the soil erosion risk in vineyards with different intensity of soil management, highlighting the importance of selecting the most appropriate SMP to be adopted in each area, in order to protect soil from erosion.

Conclusions

The preliminary results of this work suggests the effectiveness of using ORUSCAL to perform soil loss prediction with limited datasets, both for calibration purposes such as the identification of site-specific values for C-factor and for the evaluation of soil erosion risk under different intensities of soil management. It highlights the need for a thorough validation of erosion predictions. The implementation of ORUSCAL and deep analysis of results obtained in other wine-growing regions across Europe will allow to identify the C-factor and assess the erosion risk for the most common SMP. This enables a reliable application of RUSLE prediction to stakeholders for selecting the most appropriate management for a given location.

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