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Determination of long-term erosion rates in vineyards of Navarre (Spain) using botanical benchmarks: an empirical approach

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Grape production is rather an ancient and important activity in the world, particularly in Spain, that has the maximum land devoted to viticulture of any country in the world. Despite the importance of vine crop, quantification of soil erosion rates on a pluri-decennial scale under this land use all over the world, is scarce. Considering that in Navarre (Spain) grafting in vines was made until the nineties directly in the field and almost at the soil surface level, we hypothesize that quantification of erosion/sedimentation rates around a single plant may be performed by using the (large, easily-identifiable) callus formed around the graft as a palaeo-surface marker. Besides, sampling a number of vines evenly widespread in the field, an erosion/sedimentation pattern within the study vineyards may be also defined by data interpolation. Our purpose in this paper is then (i) to assess the erosion rates of some vineyards of different age in a Mediterranean environment using the aforementioned botanical signal i.e., grafting callus, and (ii) to determine the topographic changes produced by the erosion processes in these fields. In the region of Navarre (Spain), 7 rain-fed vineyards of different age (between 22 to 61 years old) and affected by soil erosion were selected as experimental plots. Then, in order to find out how far from the ground surface graft was originally made, we sought other vineyards, close and (almost) contemporary to the 7 studied ones, whose soil surface level has kept roughly invariant during the time.

On the other hand, 2 types of Digital Elevation Models (DEM) were created. (i) A DEM depicting the present land surface by using the actual elevation values of the soil surface (ii) Another DEM trying to recreate the former topography of the vineyard (i.e. that one present near the time of plantation). By performing a subtraction of the DEM representing the land surface at the moment of the plantation from the DEM of the present land surface, a new DEM quantifying the local soil loss/gain rates over the entire crop span is obtained. Some results as well as advantages and limitations of the proposed methodology are presented, herein.

The present work reveals an important overall erosion rates in vineyards of Navarre (*ca*. 3 kg m^{-2} y^{-1}) that on average (much) exceeds even the most conservative soil loss tolerance thresholds. This is an alarming finding when considering the large areas that vines and similar crops such as almonds and olives cover in (the Mediterranean region of) Spain. Moreover, the results suggest that tillage erosion is the leading soil loss process in the study vineyards rather than water erosion.

Our innovative way to determine overall rates of soil surface lowering/rising in grafted vineyards appears as a promising method to estimate (long term) erosion/sedimentation rate not only in vines but also in other crops provided a reliable botanical benchmark of the former soil surface such as graft. In addition, this technique allows a retrospective (decades in the past) determination on soil loss/gain in a cheap and simple way. Furthermore, a spatial pattern of soil loss and soil gain can also be successfully defined in the terrain. The advantage of this methodology over monitoring soil loss (e.g. plot measurement) is that data are relatively easy to obtain and no instruments have to be installed in the field.

On the other hand, this soil loss assessment may be a valuable way to, in some extent, come up with the lack of information on long-term erosion rate in cultivated areas of Navarre and Spain, as well as to validate long-term erosion models such as USLE or the like.