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Modeling soil organic carbon stock after 10 years of cover crops in Mediterranean vineyards: improving ANN prediction by digital terrain analysis

Giuseppe Lo Papa[1]; Luciano Gristina[1]; Carmelo Dazzi[1]; Agata Novara[1]

University of Palermo[1]

Estimate changes in soil organic carbon (SOC) stock after Agro Environment Measures adoption in Europe are strategically for national and regional scales. Uncertainty in estimates also represents a very important parameter in terms of evaluation of the exact costs and agro-environment payments to farmers. In this study we modeled the variation of SOC stock after 10-year cover crop adoption in a vine growing area of South-Eastern Sicily. A paired-site approach was chosen to study the difference in SOC stocks. A total 100 paired sites (i.e. two adjacent plots) were chosen and three soil samples (Ap soil horizons, circa 0-30 cm depth) were collected in each plot to obtain a mean value of organic carbon content for each plot. The variation of soil organic carbon (SOC_v) for each plot was calculated by differences between contents of the plot subjected to cover crops (SOC_{10}) and the relative plot subjected to traditional agronomic practices (SOC_0). The feasibility of using artificial neural networks (ANN) as method to predict soil organic carbon stock variation and the contribution of digital terrain analysis to improve the prediction were tested. We randomly subdivided the experimental values of SOC-stock difference in 70 learning samples and 30 test samples for model validation. SOC_v was strongly correlated to the SOC_0 content. Model validation using only SOC_v as unique covariate showed a training and test perfection of 0.632 and 0.771 respectively. We hypothesized that terrain-driven hydrological flow patterns, mass-movement and local micro-climatic factors could be responsible processes contributing for SOC redistributions, thus affecting soil carbon stock over time. Terrain attributes were derived by digital terrain analysis from the 10 m DEM of the study area. A total of 37 terrain attributes were calculated and submitted to statistical feature selection. The Chi-square ranking indicated only 4 significant covariates among the terrain attributes (slope height, valley depth, protection index, surface area). Model validation using SOC_v and the selected terrain attributes as predictors showed a training and test perfection of 0.889 and 0.921 respectively. Results confirmed that after 10 years of cover crop practices the SOC contents generally increased in the topsoil horizon and this increment is affected by the initial SOC content and terrain-driven factors.

Keywords: SOC stock modeling, vineyards, cover crops, digital terrain analysis, artificial neural network