Soil Organic Carbon and Nitrogen Stratification as an Indicator of Soil Quality in the Vineyards of Ravi Kotari, Croatia

Lydia A. Palumbo1, C. Brannon Andersen1, Gregory P. Lewis2, and Mia Birkjäa2

1 Department of Earth and Environmental Sciences, Furman University, Greenville, SC
2 Department of Biology, Furman University, Greenville, SC
3 Department of Ecology, Agronomy, and Aquaculture, University of Zadar, Zadar, Croatia

Abstract

Soil degradation, especially the loss of organic carbon, in the Mediterranean region may pose significant threats to the region’s wine industry. However, little is known about the condition of the Mediterranean agricultural soils associated with viticulture in Croatia. Four vineyards under different management styles were studied in Ravni Kotari, Croatia, to compare the effect of soil management on the content of soil organic carbon (SOC) and organic nitrogen (SON), C/N ratio, and stratification ratios of soil organic matter. The four vineyards were characterized by calcareous clay loams and terracotta, which pose challenges for viticulture because grapes require well-drained soils. Calcium was removed from soils prior to analyzing SOC and SON. In the non-carbonate fraction, SOC ranged from 5.04±0.7% and SON ranged from 0.42±0.1% for depths to 18 cm. No-CO2, burnt stone soils with a high carbonate fraction, and two-tillled soils had intermediate SOC and SON that did not decrease with depth and the lowest C/N ratios.

Introduction

• Croatian soils are classified as degraded and have been cultivated for thousands of years; jet little is known regarding their current condition.
• Degraded soil in the wine-producing regions threaten the economy in terms of sustainability and resilience to the climate changes predicted to occur in Europe (Bird, M., et al., 2011).
• Vineyards are unique in the soil qualities that are most producible. These soils are clay rich, however, vine grapes require well-drained soils and have relatively low nutrient demands. Increased soil organic matter (SOC) would improve soil aggregation and increase water drainage.
• In this study, we compared the C/N ratio and SOC and SON and stratification ratios of tilled versus no-till soil management styles to better understand the impact of soil treatment on soil fertility for viticulture.
• Research by Frankel-Weathers (2002) suggests that the stratification ratio of organic carbon and organic nitrogen (SON) is related to SOC.
• We hypothesized that SOC stratification ratios would be higher in no-till vineyards based on Frankel-Weathers (2002) findings that no-till management yields higher stratification ratios than conventional till.

Methodology

Chaparral and Woodland sites

Regional map of study area in Croatia and vineyards locations in the Ravni Kotari region near Zadar, Croatia.

Bastica Vineyard

• 339 total samples were collected. 35 soil profiles 18 cm deep were collected in Bastica, Skalik, and Nadin and divided into 2 cm subsamples in the field. 20 homogenous cob samples were collected in King’s vineyard to 10 cm deep. Four non-agriculture profiles were collected from chaparral and woodland locations, and subdivided into 2 cm subsamples for comparison.
• Soils were calcareous clay loams and terracotta (Skalik) and Nadin vineyards were located in the Nadin valley. These soils were used for comparison with vineyard soils that were the terracotta clay loams formed on Cretaceous limestone. Bastica vineyard soils are formed on Eocene marls.
• Preliminary XRD analysis indicated little and kaolinite comprised the clay fraction, and quartz and calcite were the primary minerals in the calcium fraction.
• Calcium carbonate was removed from the samples prior to organic SOC and SON analysis using 1% hydrochloric acid. Samples were rinsed with distilled water to remove calcium ions. SOC and SON content of the non-carbonate fraction was measured using a LECO TruLab Series CN Microsampler.

Bastica Vineyard: No-till conventional used chemical fertilizers, pesticides, and copper sulfate fungicide.

Nadin Vineyard: Tilled and conventional fertilizers and pesticides with copper sulfate fungicide.

Skalik Vineyard: Tilled and organic fertilization. They used organic fertilizer (fruit tea pellets) and copper sulfate fungicide.

Results and Discussion

• Graphs (left) show vineyards in agricultural soil properties, including chaptalization and woodlands, to compare to vineyards. Graphs (right) show vineyards in agricultural soil properties, including chaptalization and woodlands, to compare to vineyards.
• Graphs below show trends in SOC, SON, and C/N ratios for all four vineyards for 0-10 cm depth. These vineyards had the highest SOC, %SON, and C/N ratio. Bastica had the second highest %SOC and C/N ratio.
• The stratification ratios (right) for %SOC and %SON indicate that Bastica has the highest soil quality based on these quality indicators.

Conclusions and Future Research

• The no-till soils from Bastica and King’s show higher %SOC and C/N ratio than soils under tillage. These results support previous research by Frankel-Weathers (2002), indicating that soils under no-till management had higher stratification ratios. There is very little literature on stratified soil SOC and stratification ratios. However, studies have shown that SOC sequestration is higher in organically managed soils (Gattinger, et al., 2012). The conclusions of these studies are supported by the high SOC and SON stratification ratios in Bastica and Skalik, and indicates that they have better soil quality due to management practices. King’s vineyard, though having the highest %SON, %SOC, and C/N ratio, could not be stratified for soil ratios because profiles could not be collected. However, the results show that no-till farming in Bastica leads to higher SOC content.
• This research is important for understanding Croatia’s wine industry with future climate changes. Agriculture in the Mediterranean is expected to be sensitive to global climate change and its impacts. Mediterranean viticulture is currently under stress from degraded soils and spreading fungal infestations due to changing climate conditions. Diminishing Croatia's ecological and environmental sustainability from soil research is needed to document current soil health and identify standard soil quality indicators.
• Future research will calculate the data of C and N in the soils. The data above only account for soil properties from the non-carbonate fraction, which was removed during HC2 acidification. Estimating total carbon and nitrogen present in the soil will require carbonate content data and bulk density data. In addition, different vineyards in the Ravi Kotari region will be analyzed as well as soil analysis of mineral composition.

References

1 Bird, M. and Olesen, J.E., 2011. The response of agriculture in Europe to climate change: Regional Environmental Changes, p. 151-158.

Acknowledgements

Many thanks to the faculty at the University of Zadar for their contributions, specifically Marin Perisic and Hrvoje Grcanac, and to Furman University Office of Undergraduate Research and Internships, specifically Timothy Yeton, for supporting this research.