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 Brikjačić3
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 Ravi 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 terra rossa, which pose challenges for viticulture because grapes require well-drained soils. Treatment was removed from soils prior to analyzing SOC and SON. In the non-carbonate fraction, SOC ranged from 1.04±0.87 to 8.02±0.87 %, and SON ranged from 4.06±0.82 to 7.04±0.81 %. No visible closed stone with a diameter of >1 cm (till) was observed in the soil profile. Tilled 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, yet little is known regarding their current productivity.
• Degraded soil in the wine producing regions threatens the economy in terms of sustainability and resilience to the climate changes predicted to occur in Europe (Bink, M. et al., 2011).
• Vineyards are unique in the soil qualities that are most productive. These soils are clay rich, however, wine 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 ratios and SOC and SON 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 Balaž et al. (2002) suggests that the stratification ratio of organic carbon and organic nitrogen content is needed to support sustainable viticulture.
• We hypothesized that SOC stratification ratios would be higher in no-till vineyards based on Balaž et al. (2002) findings that no-till management yields higher stratification ratios than conventional till.

Methodology

• 339 total samples were collected. 35 soil profiles 18 cm deep were collected in Bastica, Skalj, and Nadin and divided into 2 cm subsamples in the field. 29 homogenous grab samples were collected in King’s vineyard to 10 cm deep. Four non-agricultural profiles were collected from champeal and woodland locations, and subdivided into 2 cm subsamples for comparison.
• Soils in Bastica, Skalj, and Nadin are calcareous clay loams and terra rossa. Soil samples were collected at a depth of 18 cm from the soil surface. In King’s vineyard, soil samples were collected from the top 10 cm and mixed to form a composite sample.
• Preliminary XRF analysis indicated the soils were comprised of two primary minerals: and calcium carbonate. No visible closed stone with a diameter of >1 cm (till) was observed in the soil profile. In the non-carbonate fraction, SOC ranged from 1.04±0.87 to 8.02±0.87 %, and SON ranged from 4.06±0.82 to 7.04±0.81 %.

Results and Discussion

• The no-tiller soils from Bastica and King’s show higher %SOC and C/N ratio than soils under tillage. These results support previous research by Balaž et al. (2002) indicating that soils under no-till management had higher stratification ratios. There is very little literature on stratified soil C/N and stratification ratios. However, studies have shown that SOC stratification is higher in organically managed soils (Gelletly, et al., 2012). The conclusions of these studies are supported by the high SOC and SON stratification ratios in Bastica and Skalj, and indicate that they have better soil quality due to management practice. King’s vineyard, though having the highest %SOC, %SON, and C/N ratio, could not be analyzed for stratification ratio because profiles could not be collected. However, the results do 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 likely to experience pressure from increasing soil organic matter degradation due to warming temperatures, precipitation of, and pests. The no-till approaches studied here show promise in reducing these effects.
• Mediterranean viticulture is currently under stress from degraded soils and spreading fungal infestations due to changing climate conditions. Increased Croatia’s economic and environmental sustainability from soil research is needed to document current soil health and identify standard soil quality indicators.
• Future research will calculate the mass of C and N in the soils. The data above only account for soil properties from the non-carbonate fraction, which were removed during HCI acidification. Estimating total carbon and nitrogen sequenced in the soil will require carbon and nitrogen data and bulk density data. In addition, additional vineyards in the Ravi Kotari region will be analyzed as well as full analysis of mineral composition.

Conclusions and Future Research

• The no-tiller soils from Bastica and King’s show higher %SOC and C/N ratio than soils under tillage. These results support previous research by Balaž et al. (2002), indicating that soils under no-till management had higher stratification ratios. There is very little literature on stratified soil C/N and stratification ratios. However, studies have shown that SOC stratification is higher in organically managed soils (Gelletly, et al., 2012). The conclusions of these studies are supported by the high SOC and SON stratification ratios in Bastica and Skalj, and indicate that they have better soil quality due to management practice. King’s vineyard, though having the highest %SOC, %SON, and C/N ratio, could not be analyzed for stratification ratio because profiles could not be collected. However, the results do 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 likely to experience pressure from increasing soil organic matter degradation due to warming temperatures, precipitation of, and pests. The no-till approaches studied here show promise in reducing these effects.
• Mediterranean viticulture is currently under stress from degraded soils and spreading fungal infestations due to changing climate conditions. Increased Croatia’s economic and environmental sustainability from soil research is needed to document current soil health and identify standard soil quality indicators.
• Future research will calculate the mass of C and N in the soils. The data above only account for soil properties from the non-carbonate fraction, which were removed during HCI acidification. Estimating total carbon and nitrogen sequenced in the soil will require carbon and nitrogen data and bulk density data. In addition, additional vineyards in the Ravi Kotari region will be analyzed as well as full analysis of mineral composition.

References


Acknowledgements

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