Effect of tequila vinasses application to an agricultural soil on carbon and nitrogen mineralization

Rene G. Moran-Salazar[1], E. Nahomy Marino-Marmolejo[2], Gustavo Davila-Vazquez[1], Marco L. Luna-Guido[3], Luc Dendooven[3], Silvia M. Contreras-Ramos[1]*

[1] Unidad de Tecnología Ambiental, Centro de Investigación y Asistencia en Tecnología y Diseño del Estado de Jalisco, A.C. (CIATEJ), Av. Normalistas 800 Col. Colinas de la Normal, 44270 Guadalajara, Jalisco, Mexico.

[2] Unidad de Biotecnología Médica y Farmacéutica, CIATEJ.

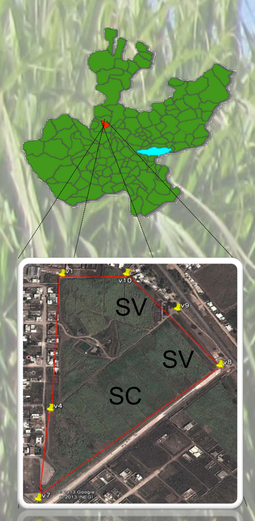
[3] Laboratorio de Ecología de Suelos, ABACUS, Cinvestav, Mexico

* Corresponding author: smcontreras@ciatej.mx; smcontrerasr@gmail.com; renemoran999@gmail.com

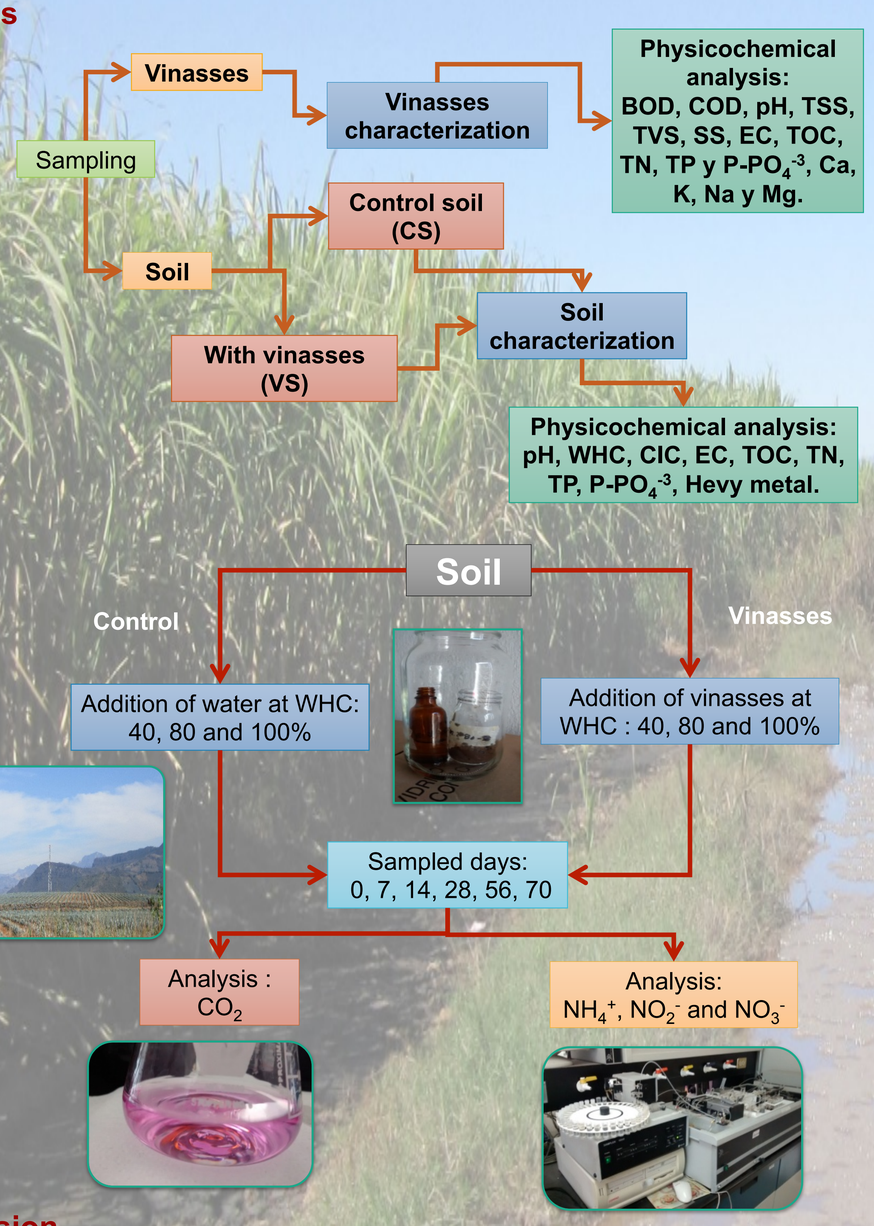
I. Introduction

The application of tequila vinasses to soil is a common practicum in Jalisco, Mexico. Vinasses are wastewater from tequila process and every liter of tequila generates around 10 L of vinasses, producing 1,647 million L of vinasses in 2013 (55% Alc. Vol.). It is thinking that the high organic matter content from vinasses could be beneficial into the soil; however, studies about carbon and nitrogen mineralization by tequila vinasses applications to soil had not been reported. The objective of this study was evaluates the mineralization of carbon and nitrogen by tequila vinasses application.

II. Material and Methods



"El Arenal", Jalisco (20°46'7" N and 103°41'18" O)



III. Results and Discussion

Vinasses had 25,367 mg L^{-1} COD, 57,762 mgL^{-1} BOD, 16,800 mg L^{-1} TOC and 4,165 mg L^{-1} TN with acid pH. The soils had a neutral pH, were very strongly saline due to its high EC (80 mS cm^{-2}) and CIC (26 Cmol kg^{-1}, low content of NH_4^+, NO_2^- and NO_3^- (0.05, 0.02 and 0.5 mg kg^{-1} respectively) were found but had a high TN content (1,115 mg kg^{-1}) . The content of PO_4^{-3} and TP was low (0.1, 2.4 mg kg^{-1}), and the OM was medium (84,074 mg kg^{-1}) according to Mexican standard of fertility NOM-021-SEMARNAT-2006.

Control and vinasses soil at WHC 100% had highest mineralization of C in 70 days (1013 mg kg^{-1} , 5595 mg kg^{-1}) that WHC 80% and 40% (Figure 1). Vinasses addition increased 5.5, 5 and 1.2 times the C mineralization compared to control soil, at WHC 100%, 80% and 40% respectively. In similar studies Zhu et al. [2] reported higher C mineralization in a Chinese milk vetch crop soil, which was added 77.4 mg N kg^{-1} and at WHC 90% compared with a soil without nitrogen addition.

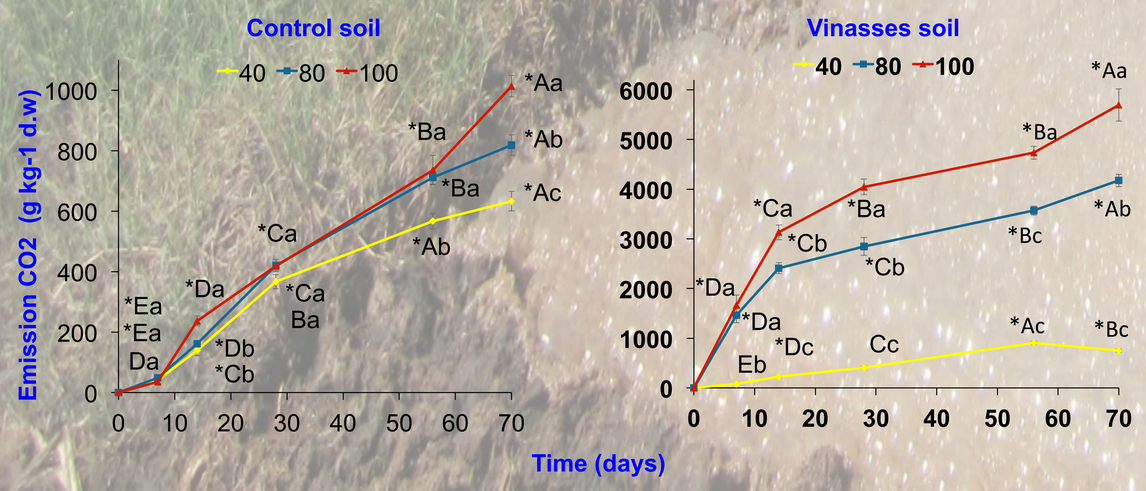


Figure 1. Carbon mineralization in control soil and vinasses soil under different WHC. Different small letters mean significant differences between WHC at same time, while different capital letters mean significant differences between different times at same WHC. *means significant differences between control and vinasses soil.

The content of ammonium in control and vinasses soil in all WHC had a significant decrease after 28 day (Figure 2a, b). The highest ammonium concentration was found with WHC 100% at 28 days in vinasses soil. Nitrite content decreased after 28 day with significant differences in all the treatments in both soils (control and vinasses). The maximum concentration of nitrite was found with WHC 100% at 28 days regardless of vinasses addition. The highest nitrates concentration was found with WHC 40% to the 70 days in control soil, while WHC 80% and 100% had a significant decrease after 28 days. Nitrogen mineralization is given mainly by the concentrations of nitrate in the soil. In vinasses soil the N mineralization had a significant decrease in the three WHC after 28 days (Figure 2g, h).

These declines can be attributed to losses of inorganic nitrogen by denitrification process, because this process is produced at 60% water saturation in the soil [3]. In that situations, the anaerobic microorganisms use inorganic compounds such as NO_3^- to oxidize the organic matter instead of O_2 as final acceptor of electrons [4]. In WHC 40% had not a decrease in the nitrate content, suggesting that remained the nitrification and aerobic conditions. However, the nitrogen mineralization was observed at WHC 80 and 100% during the first 28 days. This possibly was due to that into the soil there were micro sites available with O_2 for the oxidation from organic matter.

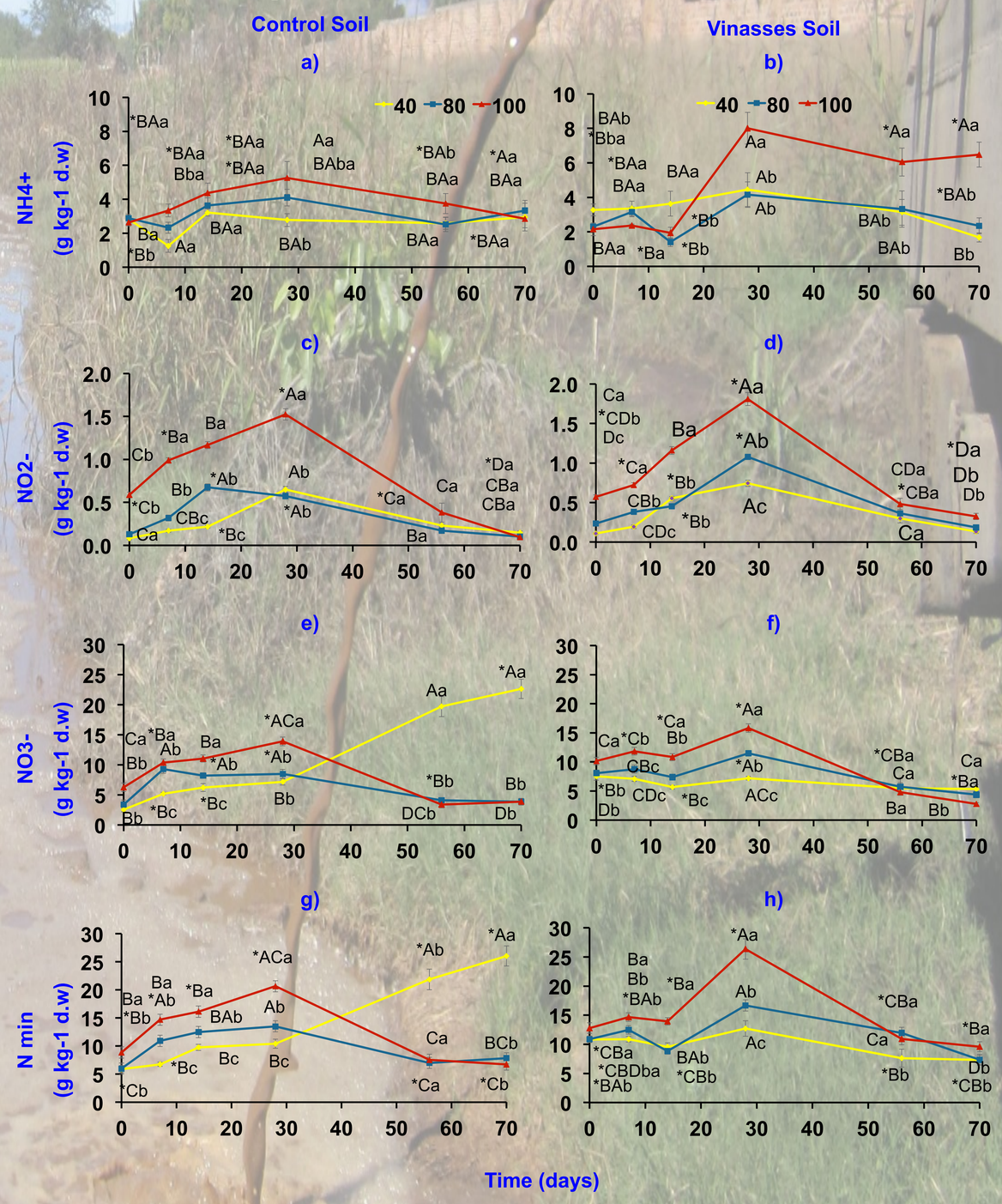


Figure 2. Nitrogen mineralization with tequila vinasse addition at different WHC in control and vinasses soil. Different small letters mean significant differences between WHC at same time, while different capital letters mean significant differences between different times at same WHC. * means significant differences between control and vinasses soils.

IV. Conclusions

The addition of vinasses to the soil increases carbon mineralization up to 5 times more than in a soil without vinasses both under anaerobic conditions (WHC 100% and 80%) in 70 days. An increase in the nitrogen mineralization was observed in control soil at WHC 40%, indicating that there was not inhibition of the nitrification path. However in the soil added with vinasses after 28 days that path was inhibited at all WHC tested.

Acknowledgments

This research received support by 'Consejo Nacional de Ciencia y Tecnología (CONACYT)' Mexico, into the fund SEP-CONACYT-Ciencia Básica with project 181070. Authors grateful that Morán-Salazar R.G. received a scholarship from CONACYT to realize this research.

References

(1) Luna-Guido, M. L., J. Vega, A. Ponce-Mendoza, H. Hernández-Hernández, et al. Mineralization of 14C-labelled maize in alkaline saline soils. Plant Soil, 2003, 250, 29-38.
(2) Zhu, T., J. Zhang, W. Yang and Z. Cai Effects of organic material amendment and water content on NO, N2O, and N2 emissions in a nitrate-rich vegetable soil. Biol. Fert. Soils, 2013, 49, 153-163.
(3) Reddy, K. R. and W. H. Patrick Effect of alternate aerobic and anaerobic conditions on redox potential, organic matter decomposition, and nitrogen loss in a flooded soil. Soil Biological Biochemistry, 1975, 7, 87-94.
(4) Stevenson, F. J. and M. A. Cole Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulfur and Micronutrients. edited by J. WILEY. Edtion ed. New York, 1999.