Greenhouse gases emissions by irrigation of tequila vinasses in an agricultural soil

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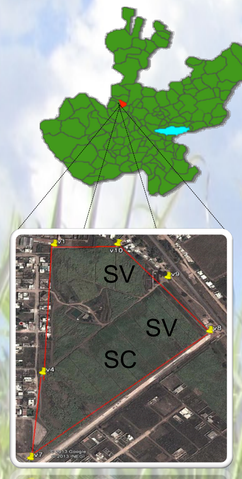
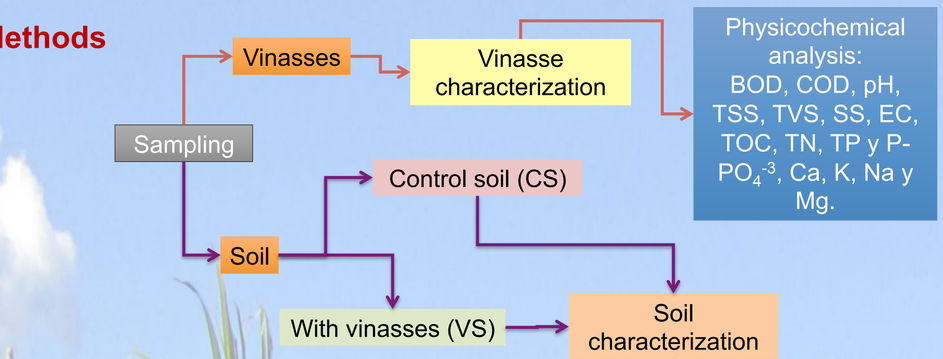
I. Introduction

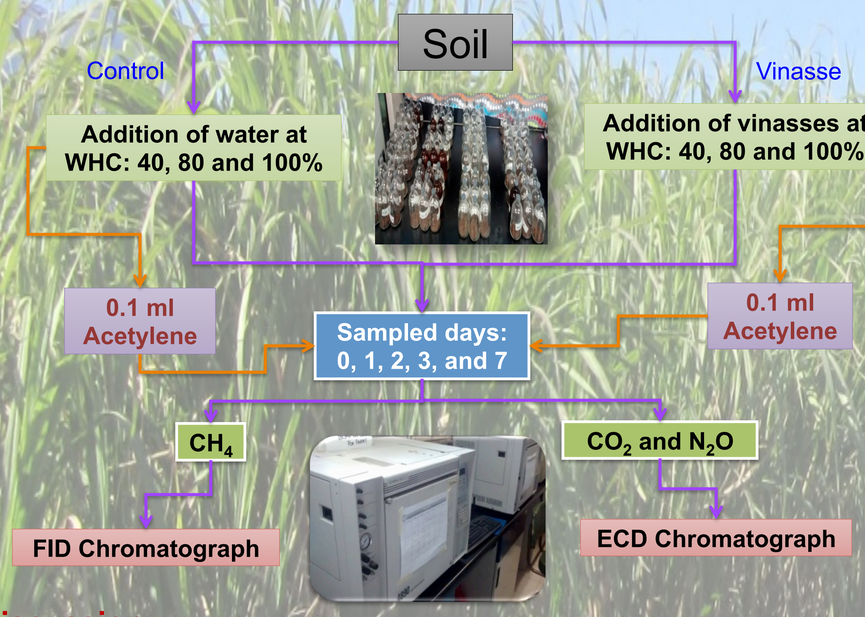
In Jalisco state from Mexico, the irrigation of agricultural soils with waste wastewater form tequila process, which are called "vinasses", it is a common practicum. These vinasses are generated after tequila distillation and every litter of tequila generates around 10 L of vinasses, producing 1,647 million L of vinasses in 2013 (55% Alc. Vol.). Due the high organic matter content from that vinasses are irrigated as nutrients source to soil. However, studies about emission of greenhouse gases (GHG) by tequila vinasses applications had not been estimated. The aim of this study was to evaluate the generation of GHG (CO_2, N_2O and CH_4) after vinasses application in agricultural soil under laboratory conditions.

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.

The production of CO_2 was higher in 80 and 100% WHC in both soils + acetylene that WHC 40%, with a significant increase after 3 day. The treatments without acetylene had the same behavior but showed significantly lower emissions of CO_2 than that treatments added with acetylene (Figure 1). This difference is explained by that the acetylene can be oxidized under aerobic and anaerobic conditions [1]. The addition of vinasses increased two times more the emission CO_2 than in control soils at 100 and 80% WHC (treatments without acetylene) (Figure 1).

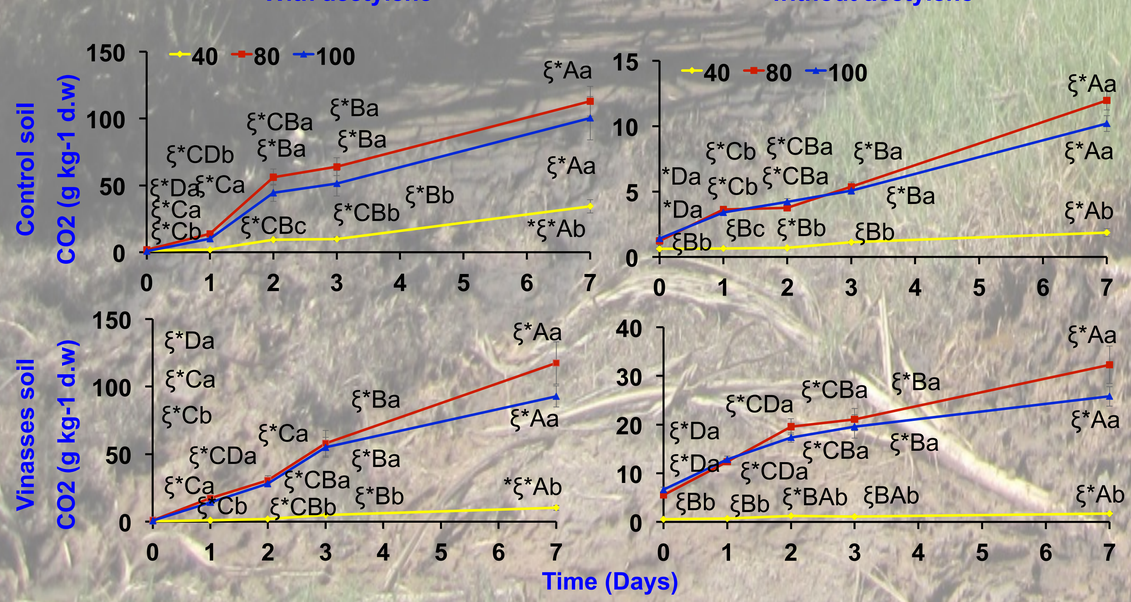


Figure 1. CO2 emission in control and vinasse soil with and without acetylene at different WHC. Different small letters mean significant differences between WHC at same time, while different capital letters mean significant differences between different times at same WHC. * Means significant differences between control and vinasses soils. ξ Means significant differences between with or without acetylene treatments.

Vinasses soil with acetylene had the highest increase in N_2O production during the first 3 days at 80 and 100% WHC with a concentration of 0.21 and 0.28 mg kg^{-1} respectively ($p < 0.05$). Treatments without acetylene had a similar behavior, but with a lower concentration of N_2O than with acetylene. There was not significant differences between treatments with and without acetylene for vinasses soil. This indicated that the emission of N_2O was due to the addition of vinasses and by the path of denitrification. Similarly Rodriguez et al. [2] found that in different WHC (40, 60, 80 and 100%), N_2O increased to highest WHC.

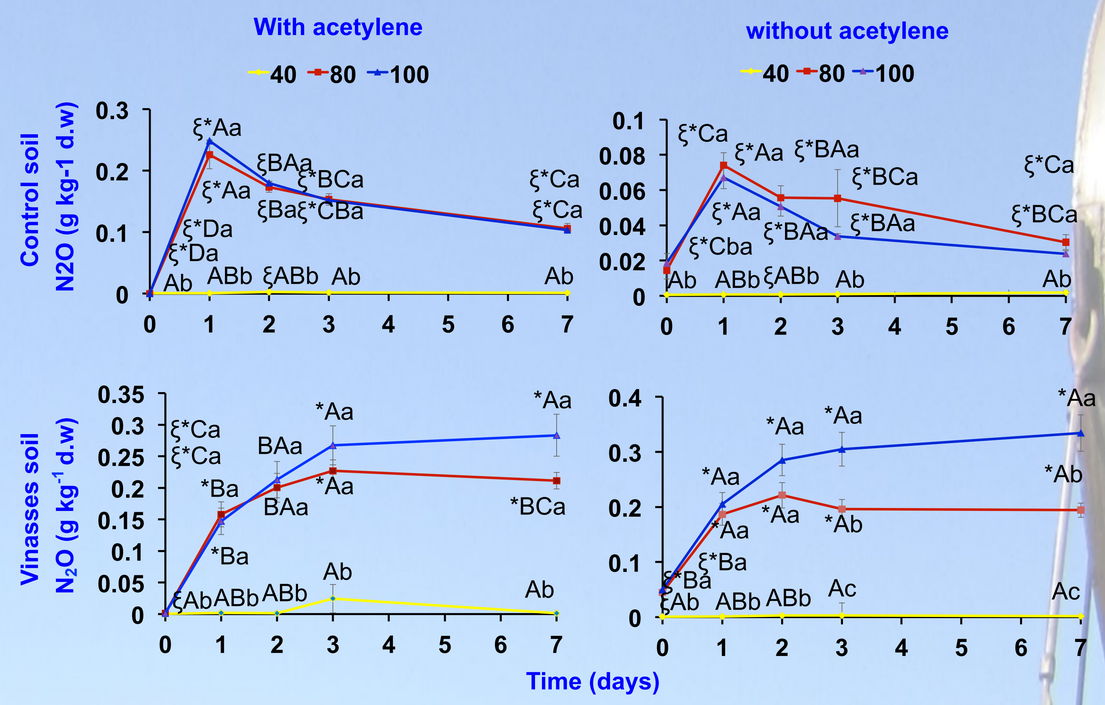


Figure 2. N_2O emission in control soil and vinasses soil with and without acetylene under different WHC. Different small letters mean significant differences between WHC at same time, while different capital letters mean significant differences between different times at same WHC. * Means significant differences between control and vinasses soils. ξ Means significant differences between with or without acetylene treatments.

Methane (CH_4) emission presented significant differences between the control and vinasses soil with acetylene in 3 and 7 days for the treatments at WHC 80 and 100% (Figure 3). For the control soils without acetylene, treatments with WHC 80 and 100% showed a slight increase after day 3 ($p < 0.05$). The emission of CH_4 in the vinasses soil without acetylene was significantly higher at 3 and 7 days than that found in control soil without acetylene. There were not significant differences with and without the addition of acetylene for both soils (Figure 3). This indicated that the emission of CH_4 was favored with the anaerobic conditions and with high amount of organic matter in the soil [3].

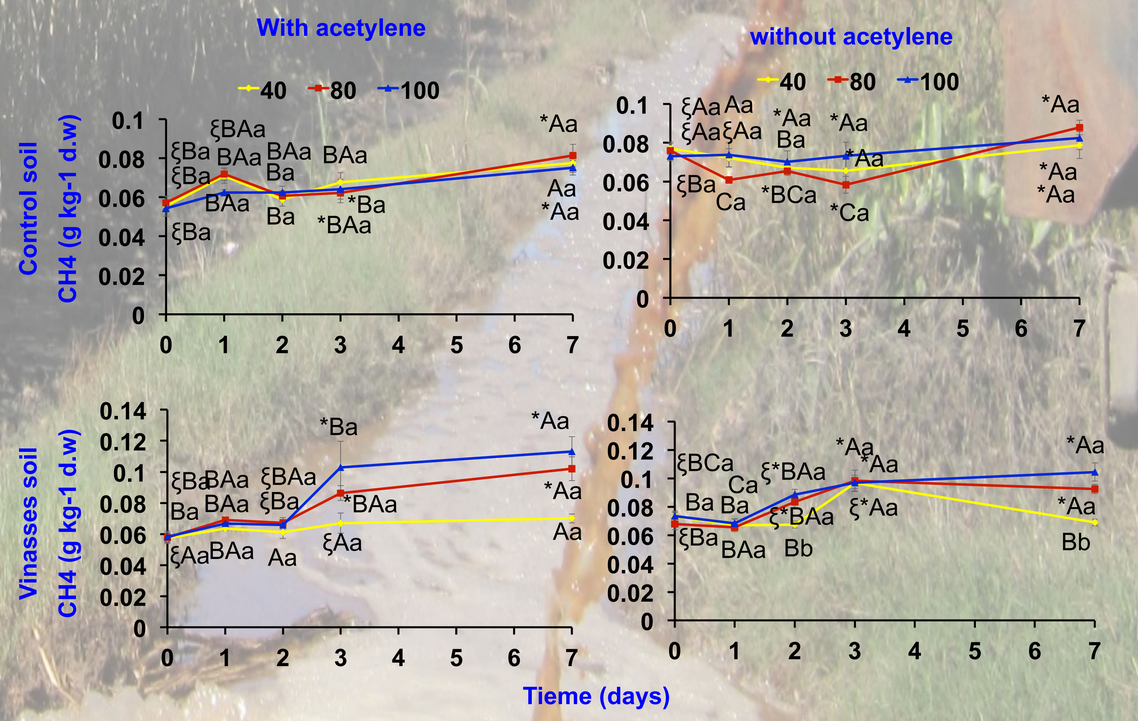


Figure 3. CH_4 emission in control and vinasses soil with and without acetylene at different WHC. Different small letters mean significant differences between WHC at same time, while different capital letters mean significant differences between different times at same WHC. * Means significant differences between control and vinasses soils. ξ Means significant differences between with or without acetylene treatments.

IV. Conclusions

The addition of vinasses increased the emissions of CO_2, N_2O, and CH_4 at WHC 80 and 100%, where there were anaerobic conditions. A highest emission was found for CO_2 (117.5 mg kg-1) that N_2O, and CH_4 at WHC 100%. The highest emissions of N_2O were by the denitrification way in vinasses soil at WHC 80 and 100%. A minimum emission of CH_4 was found by effect of the addition of vinasses.

Acknowledgments

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