MICROBIAL NETWORKS IN CONTROL OF GREENHOUSE GASES EMISSIONS IN BIO-BASED AGRICULTURE (MINIBAG)

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Figure 1. Vinasse, produced at a rate of 10-13 liter per liter of ethanol, is recycled in the field adding organic matter and nutrient to soils

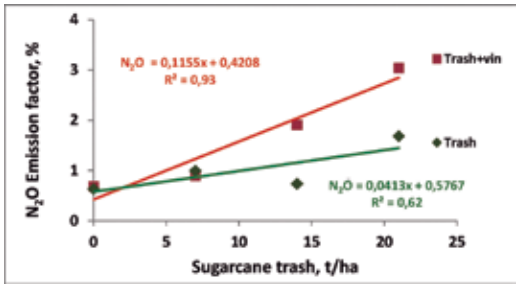

Figure 2. Vinasse and sugarcane straw increase N_2O emission from N fertilization. The N_2O emission factor increases 0.04% per tonne of straw or trash but when vinasse is applied the N_2O emission factor increases three times more. Data adapted from Carmo et al, 2013

Soils are considered principally non-renewable resources. Soil ecosystem services have a large impact on numerous societal demands and are of high economic importance. Within the area of sustainable agriculture, it is expected that agricultural production will increasingly rely on the natural nutrient retention and recycling capabilities of soil. The project described here seeks to provide a fundamental scientific understanding of soil functioning and the resulting ecosystem services in Brazilian and Dutch bio-economies based on innovative microbial ecology and soil science studies. Focus will be in sugarcane production systems by linking soil-borne microbial composition and functioning, waste residues recycling, fertilizers, soil factors and greenhouse gases (GHG) emissions through integrating and complementing the strong expertise of Brazilian and Dutch researchers. In Brazil, we will quantify the microbial functional groups and microbial abundance of C and N cycle genes and measure GHG emissions (CO_2, CH_4 and N_2O) from soils during the productive cycle of the plant under different management practices and verify the temporal and spatial variability of these emissions in the evaluated treatments with different concentrations of sugarcane vinasse residue combined with N mineral fertilizers and with straw additions, and determine the conditions under which such GHG emissions can be counteracted, or minimized. In Netherlands, we will focus on the rules of microbial functional groups, microbial N and C genes, organic matter content/type, GHGs emissions and soil factors on soil quality.

Previous studies of our group (Carmo et al., 2013, Soares et al., 2015) had shown that the emission factor of N fertilizer in ratoon sugarcane is within or more generally below the 1% value suggested by IPCC. However, the presence of sugarcane straw or trash, especially in combination with vinasse, enhances GHGs emissions much above the values of IPCC (Carmo et al., 2013), which contribute to decrease the very good GHGs balance of bioenergy produced with sugarcane.

The strategy behind the present project is to do examine possibilities of reducing GHGs emissions, especially that of N_2O in this sugarcane systems where fertilization is done in fields covered with straw and the application of vinasse is part of the regular crop management due to the need to recycle this by-product in the soil.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

So far three field experiments were conducted in Brazil in which GHGs emissions were evaluated as a function of N fertilization, vinasse – both regular or concentrated application. In all sites straw derived from unburned harvesting was preserved on the soil.

The largest N_2O emission occurred when concentrated vinasse (CV) was applied together with N fertilizer, reaching 2.5% of the N applied. This emission factor was above the default emission factor of 1 % of the IPCC. However, N_2O emissions from the fertilized plots without vinasse or when vinasse application was anticipated was 0.25% of the N applied and were, therefore, well below the default value, regardless of the addition of mineral N. As a result of the atypical (much dryer) weather conditions in the 2013/2014 season, the application of regular vinasse (RV), regardless of the time of application, showed low N_2O emission. The application of N along with CV increased GHG's emissions, possibly due to the presence of both readily available C and N for the soil microorganisms. Therefore, a 1-month interval between application of CV and N seems to be a good strategy to reduce the N_2O emission.

The effects of fertilization and straw on N_2O emissions have being previously reported; however they did not take into account the microbial community. This project is showing novel information about microorganisms involved in GHGs emissions and how the microbial community varies in short time, depending on the prevailing substrates. Besides the common Proteobacteria model organisms for denitrification, we have found taxa recently described as potential drivers of N_2O production and consumption. Additionally, we have identified taxa with potential biotechnological properties that might improve the sustainability of bioethanol by increasing C yields and improving N efficiency in sugarcane fields. Preliminary results also point to the important role of nitrification as a driver of N_2O emission in sugarcane fields fertilized with N.

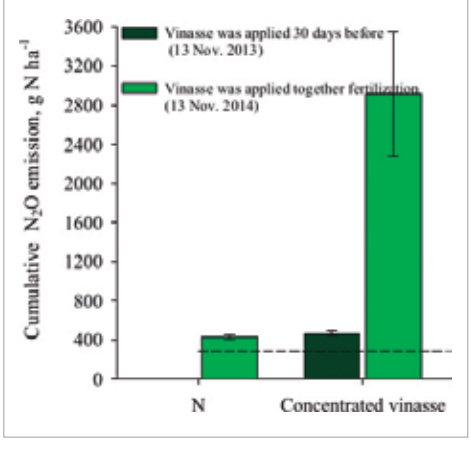

Figure 3. Separating concentrated vinasse and fertilizer application by one month sharply decreases N_2O emission

MAIN PUBLICATIONS

Carmo JB, Cantarella H, Rossetto R, Kuramae EE, Filoso S, Pitombo LM, Bento CB, Lourenço KS, Soares JR. 2014. Greenhouse gases emissions during sugarcane plantation in São Paulo State: Lessons learned during field conditions. 2nd BBEST – Brazillian BioEnergy Science and Technology Conference, Campos do Jordão, Brazil, October 20-24th, 2014.

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Kuramae EE, Pitombo LM, do Carmo J, Rosseto R, de Hollander M1, van Veen JA1, Cantarella H. BIOEN and BE-BASIC scientific integration program for control of greenhouse gases (GHG) emissions in Bio-based agriculture. 2nd BBEST – Brazillian BioEnergy Science and Technology Conference, Campos do Jordão, Brazil, October 20-24th, 2014.

Lourenço KS, Cantarella H, Lourenço LS, Sousa RM, Carmo JB, Rossetto R, Vitti AC, Vargas VP, Soares JR, Martins AA. 2014. Greenhouse gas fluxes (N_2O) from soil with sugarcane as affected by regular or concentrate vinasse in different application times. 2nd BBEST – Brazillian BioEnergy Science and Technology Conference, Campos do Jordão, Brazil, October 20-24th, 2014.

Pitombo LM, Do Carmo JB, De Hollander M, Rossetto R, López MV, Cantarella H, Kuramae EE. 2015. Exploring soil microbial 16S rRNA sequence data to increase carbon yield and nitrogen efficiency of a bioenergy crop. *Global Change Biology Bioenergy*. 10.1111/gcbb.12284 (online first).

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