

EFFECTS OF ORGANIC WASTE APPLICATION ON N₂O EMISSIONS AND N LEACHING IN SUGARCANE PLANTATION SOILS IN REUNION ISLAND

POULTNEY, D.M¹, VERSINI, A.¹, THURIES, L.¹

¹ CIRAD, UPR Recyclage et risque, 97743 Saint-Denis, La Réunion, France

INTRODUCTION

Reunion Island is a densely populated Overseas Territory of France in the Indian Ocean. There is an increasing need for waste management, given the rising population density and the associated waste production increase. This waste can take the form of human waste (sewage sludge) and livestock waste (animal manure). The primary means of valorizing this waste would be as organic fertiliser in agroecosystems. Sugarcane is the most abundant crop on the island, spanning 58 % of the 43 000 hectares allocated as agricultural territory, across 9272 farms (Agreste DAAF, 2015).

N is an essential nutrient for crop growth and development, and is frequently a limiting factor in sugarcane agroecosystems. Despite the clear benefits of N fertilisers in contributing to adequate crop nutrition, excessive amounts accumulated in terrestrial and aquatic ecosystems can lead to a significant impact on environmental quality, ecosystems, biodiversity and human health (Dobermann, 2005). Environmental impacts linked to the N cycle include the loss of N to the atmosphere in the form of nitrous oxide (N₂O) during the process of denitrification. N₂O is a major greenhouse gas contributing to global warming, and agricultural soils are the most significant anthropogenic sources of N₂O (Allen *et al.*, 2010). Excess N is also lost from soils via leaching mainly in the form of nitrates. Agricultural fertilisers are major contributors to increased concentrations of N in groundwater (Ghiberto *et al.*, 2009). Eutrophication occurs when an excess of leached N reaches fresh water, which has negative effects on marine and freshwater ecosystems, and can render the water unsuitable for human consumption.

This study, which is the research project of a Doctor of Philosophy degree, is currently in its first year of implementation. It investigates the impact of recycling agricultural organic residue on the biogeochemical cycle of nitrogen in Reunion Island. The study is conducted on a SOERE-PRO site, which is a network of long-term field experimental sites, where the objective is to observe the effects of agricultural organic waste application on the different compartments of crops. The agricultural organic waste fertilisers are sewage sludge, pig manure and poultry manure. The mineral fertiliser used is urea, which is the standard fertiliser used on sugarcane farms in Reunion.

The primary objective of this study is to determine the environmental impact of organic fertiliser, as compared to mineral fertilisation. More specifically, N₂O emissions and NO₃⁻ leaching will be assessed.

MATERIAL AND METHODS

The SOERE-PRO network in Reunion Island is closely situated to the island's capital, Saint-Denis (Lat 20°54'12.2"S, 55°31'46.6"E). The site is characterized by a tropical climate with an average annual temperature of 25°C and annual precipitation of 1650 mm. The trial was planted in March 2014 from viable buds of the R579 sugarcane variety placed with 1.5 m spacing between rows. The trial consists of 6 plots, each with a different fertiliser treatment, which is repeated in 5 blocks, with each plot made up of 6 sugarcane rows of 28 m, constituting a total plot area of 250 m².

N leaching in the soil is studied using a mixed system, consisting of porous cups under tension at depths of 10 and 40 cm; and lysimetric plates at a depth of 1 m. The vertical dynamic of DON, NH₄ and NO₃ in solution is studied in the different treatments. Finally, a mass balance of the loss of N by drainage flux at a depth of 1 m will be established with the aid of a computational model simulating hydric flux.

The annual flux of N₂O is estimated for the different treatments using 12 automatic chambers linked to a gas analyser. These semi-continuous measures allow the temporal variability of N₂O emissions to be studied, in the original context of organic waste application in tropical conditions.

RESULTS AND DISCUSSION

The amount of N found at different soil depths (10 cm, 40 cm and 100 cm) are presented for the month of fertilizer application and the first three months following application (Figure 1). The proportion of N derived from fertiliser was also calculated for the three respective depths over the first three months. For the soil depths of 10 cm, 40 cm and 100 cm, the proportion of N derived from urea fertilisation was 5.2 %, 3.4 % and 0.5 %; the proportion of N derived from sewage sludge fertilisation was 11.7 %, 5.3 % and 0.8 %; and the proportion of N derived from pig manure fertilisation was 31.7 %, 14.4 % and 0.4 % respectively.

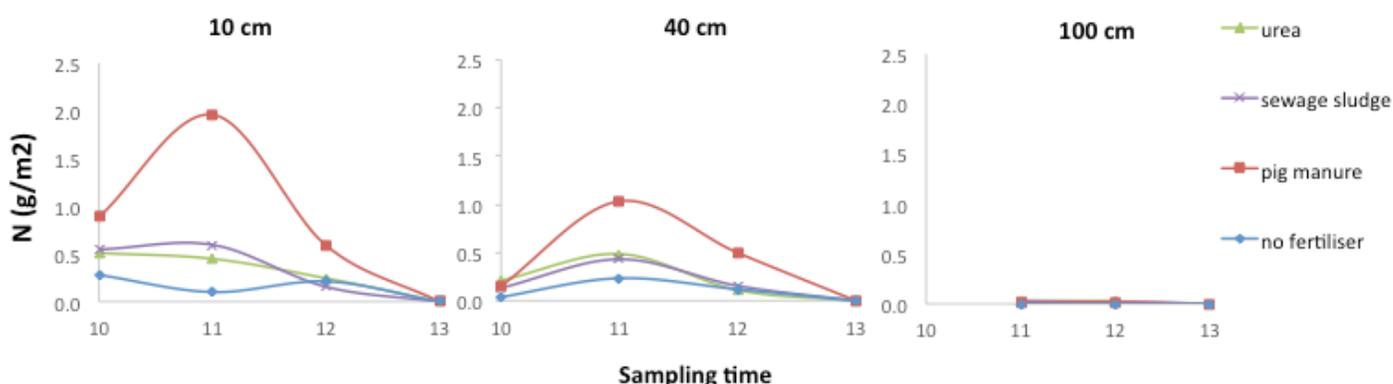


Figure 1. Nitrogen amount for the different fertiliser treatments (urea, sewage sludge, pig manure, no fertiliser) at sampling times t_0 , t_1 , t_2 , t_3 at depths of 10 cm, 40 cm and 100 cm.

There is a large increase in the quantity of N found in pig manure after the first month in the 10 cm and 40 cm soil depths, but this does not reach the 100 cm depth. The N amount in the other treatments remains relatively stable over the first month at depths of 10 cm and 40 cm. There is an overall decrease in N across treatments in the second month reaching a quantity of 0 g.m⁻² three months after fertilisation. N does not reach the 100 cm soil depth, showing that there is minimal loss of N by deep drainage during the first three months following fertilisation.

REFERENCES

- Allen, D. E., Kingston, G., Rennenberg, H., Dalal, R. C., & Schmidt, S. (2010). Effect of nitrogen fertilizer management and waterlogging on nitrous oxide emission from subtropical sugarcane soils. *Agriculture, Ecosystems & Environment*, 136(3-4), 209-217.
- Agreste DAAF La Réunion, 2015. Enquête sur la structure des exploitations agricoles en 2013. Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt – Service de la Statistique et de la Prospective. Agreste Analyses n°95.
- Dobermann, A.R., 2005. Nitrogen Use Efficiency – State of the Art. IFA International Workshop on Enhanced-Efficiency Fertilisers, Frankfurt, Germany, 28-30.
- Ghiberto, P. J., Libardi, P. L., Brito, A. S., & Trivelin, P. C. O. (2009). Leaching of nutrients from a sugarcane crop growing on an Ultisol in Brazil. *Agricultural Water Management*, 96(10), 1443-1448.