

## Management of Nitrogen Fertilizer to Reduce Nitrous Oxide (N<sub>2</sub>O) Emission and Ammonia (NH<sub>3</sub>) Volatilization from Coffee Plantation

Ana Paula Packer<sup>1</sup>, Nilza Patrícia Ramos<sup>1</sup>, Osvaldo M. R. Cabral<sup>1</sup>, Lucas R. da Silva, Rafaela C. R. M. Duarte<sup>1</sup>, Viviane C. Bettanin<sup>1</sup>, Igor M. Morasi, Ademir Rodrigo F. V. B. de Lima Amaro, Wenceslau G. Teixeira<sup>2</sup>

<sup>1</sup>Embrapa Environment, Rodovia SP 340, KM 127,5, S/N - Tanquinho Velho, Jaguariúna - SP, 13820-000, BRAZIL (paula.packer@embrapa.br)

<sup>2</sup>Embrapa Soils, Rua Jardim Botânico nº 1.024 - Jardim Botânico, 22460-000, Rio de Janeiro, RJ

### INTRODUCTION

Coffee is a key global crop and the second most valuable commodity exported by developing countries, worth around US\$19 billion in 2015. Counting with the world's largest production of coffee, Brazil is the most important player in the area and in 2016 hit the record, reaching a volume of 51.37 million bags, combining Arabica (43.24 million bags) and Robusta (7.98 million bags).

For coffee production, nitrogen (N) fertilization is an important practice because it influences directly the productivity and the coffee quality. However, an efficient N fertilization is important economically and environmentally, aiming a reduction in nutrient losses to the environment, while providing optimal crop yield (Bouwman, 1996). The main pathways of N losses from the application of fertilizers are the emission of nitrous oxide (N<sub>2</sub>O), volatilization of ammonia (NH<sub>3</sub>), leaching of nitrate (NO<sub>3</sub><sup>-</sup>) and ammonium (NH<sub>4</sub><sup>+</sup>). In general, the longer the time the N from fertilizer, organic compounds, crop residues, and etc., are available in the soil for the microbiota and without competition from the uptake by plants, the greater the N<sub>2</sub>O emission and NH<sub>3</sub> volatilization (Smith et al., 1997).

### METHODS

Evaluations were carried out during the 2015/2016 season with the determination of nitrous oxide (N<sub>2</sub>O) emission and ammonia volatilization (NH<sub>3</sub>) from the application of 300 kg N ha<sup>-1</sup> fertilizer, in the form calcium nitrate (T2), urea (T5), calcium nitrate + ammonium nitrate (T7) and a control treatment without N (T8). For commercial coffee Arabica plantation in Brazil, the fertilizer application is commonly split in tree doses, which occurs from November until March. In this trial, for T2 and T5, the application of 300 kg N ha<sup>-1</sup> was split in 120 kg N ha<sup>-1</sup> in the flowering, 90 kg N ha<sup>-1</sup> in the berry formation and 90 kg N ha<sup>-1</sup> in the berry development. For T7, in the flowering period was applied 60 kg N ha<sup>-1</sup> of calcium nitrate, followed by two ammonium nitrate applications of 120 kg N ha<sup>-1</sup>.

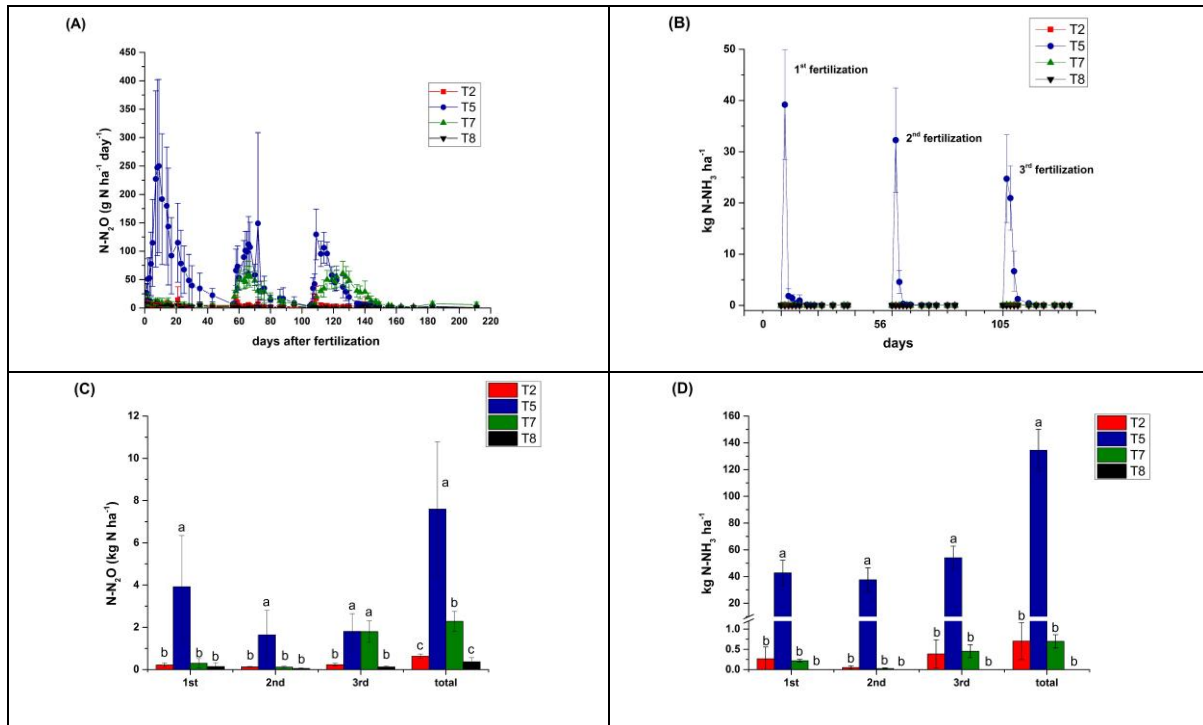
Emissions of N<sub>2</sub>O were measured using the static chamber-based method, based on trapping gases emitted from the soil surface within a chamber and collecting samples from the chamber headspace at regular intervals for analysis by gas chromatography (Hutchinson and Mosier, 1981). Two chamber were installed permanently in each treatment plot evaluated prior to the first sampling. Samples were collected daily in the first week after each N application, followed by three times a week during the subsequent month until the emissions reduction to levels similar to the control.

For the volatilized ammonia quantification, a low-cost static semi-open space (SALE) was used (Jantalia et al., 2012). The 10 cm diameter chambers were placed in duplicate in each experimental plot. A foam saturates in acid solution placed inside the chamber was used to trap de NH<sub>3</sub>. The NH<sub>3</sub> retained in the absorbers reacts to form NH<sub>4</sub><sup>+</sup> (ammonium). The N-NH<sub>4</sub><sup>+</sup> from the samples was determined by a flow injection analysis system (FIA). Samples were collected daily in the first week after each N application, followed by three times a week during the three subsequent weeks.

### RESULTS AND DISCUSSION

The N losses from the 2014/2015 season was calculated taking into account the N<sub>2</sub>O emission and the NH<sub>3</sub> volatilization from different fertilizer source. As observed from the results presented in Fig. 1,

the highest loss were from the application of urea, corresponding to 47.3 % of the total N applied, of which 44.8 % (134.4 kg N-NH<sub>3</sub> ha<sup>-1</sup>) came from the NH<sub>3</sub> volatilization and 2.5 % (7.6 kg N-N<sub>2</sub>O ha<sup>-1</sup>) from the N<sub>2</sub>O emission. For T7, the losses for both fertilizer applied was 2.6 %, where 0.9 % (0.30 kg N-N<sub>2</sub>O ha<sup>-1</sup> and 0.22 kg N-NH<sub>3</sub> ha<sup>-1</sup>) was from the application of calcium nitrate and 1.7 % (3.6 kg N-N<sub>2</sub>O ha<sup>-1</sup> and 0.48 kg N-NH<sub>3</sub> ha<sup>-1</sup>) from ammonium nitrate. The NH<sub>3</sub> volatilized from T2 corresponds to 0.23 % of the N applied (0.70 kg N ha<sup>-1</sup>) and the N<sub>2</sub>O emission to 0.21 % (0.63 kg N-N<sub>2</sub>O ha<sup>-1</sup>).



**Fig. 1.** Daily N<sub>2</sub>O emission (A) and NH<sub>3</sub> volatilization (B) after the application of different mineral N fertilizer forms T2 (calcium nitrate), T5 (urea), T7 (calcium nitrate + ammonium nitrate) and T8 (control). Cumulative N<sub>2</sub>O emission (C) and NH<sub>3</sub> volatilization (D). Treatments with the same letter were not significantly different (ANOVA with Tukey-HSD, p < 0.05).

## CONCLUSIONS

Fertilizer losses throughout emission and volatilization were in descending order: urea > calcium nitrate + ammonium nitrate > calcium nitrate. For coffee nutrition, the right source of N can reduce losses by volatilization and emission. As presented, losses for the urea application can reach 50 % of the total N applied.

## ACKNOWLEDGEMENTS

Authors acknowledge Yara Fertilizer for the financial support and experience exchange.

## REFERENCES

- Bouwman, A. F. (1996). Direct emission of nitrous oxide from agricultural soils. *Nutr. Cycl. Agroecosys.* 46: 53-70.
- Hutchinson, G. L., and Mosier, A. R. (1981). Improved soil cover method for field measurement of nitrous-oxide fluxes. *Soil Sci. Soc. Am. J.* 45:311-316.
- Jantalia, C. P., Halvorson, A. D., Follett, R. F., Alves, B. J. R., Polidoro, J. C., and Urquiaga, S. (2012). Nitrogen Source Effects on Ammonia Volatilization as Measured with Semi-Static Chambers. *Agron. J.* 104:1595-1603.
- Smith, K. A., McTaggart, I. P., and Tsuruta, H. (1997). Emissions of N<sub>2</sub>O and NO associated with nitrogen fertilization in intensive agriculture, and the potential for mitigation. *Soil Use Manage.* 13: 296-304.