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Embrapa

Nitrous Oxide Emission of Fertilizer Nitrogen with Biochar

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Introduction

The Brazilian agriculture, which accounts for more than a third of national GHG emissions, increased its emissions by 44% in the period of 1995-2010 (MCTI, 2013), being the agricultural soils increased their emissions in 55.6 Gg CO_2 eq. The corn crop, according to CONAB (2015), the 2014/15 agricultural year was the second summer crop in terms of higher productivity (5382.0 kg ha^{-1}) and planted area (15743.7 ha).

The N_2O, although in smaller amount in the atmosphere when compared to CO_2, has potential of retention infrared radiation 310 times higher (MCTI, 2013). In the agriculture the emissions of this gas are given by complex microbial processes associated with human management practices on ecosystems (FAO, 2014), nitrification and denitrification reactions, which are the main regulators of the release of N_2O. These processes are highly influenced by mineral or organic nitrogen fertilizer, plants fixing atmospheric N or application of animal waste.

The great current challenge is to reduce the N_2O emissions associated with nitrogen fertilization in cereals. According to the IPCC, 1% of the N applied to the soil via fertilizer ends in the atmosphere as N_2O. In view of this, there are several studies that suggest that biochar can play a positive role in reducing emissions of N_2O. The biochar, organic matter carbonized under poor atmosphere in oxygen (pyrolysis) whose purpose is agricultural use, aimed at the carbon capture in the soil and the improvement of their physical and chemical properties (Sohi, 2012), was considered by Fox & Chapman (2011) one of the nine most viable strategies to mitigate global warming.

Biochar influences N_2O emissions from soil due influence on the dynamics of nitrogen

(N) in the soil, affecting the availability of N to microbial action by the use of soil biochar (Clough et al., 2013), reducing the substrate of nitrification and denitrification reactions. The high ratio of C / N of biochar can favor N microbial immobilization (Cayuela et al., 2013th), in this sense the soil conditioning biochar residue derivative with low C / N ratio generates an increased release of N emanated from biochar (Cayuela et al., 2013b). Also, may occur a decrease in the availability of mineral N as result of an increase in the adsorption of NO_3^- and NH_4^+ (Yang et al., 2015). Another mechanism assists in mitigating N_2O emissions is the increase of reductive activity provided by functional groups of biochar, leading to greater efficiency of denitrification emitting thereby N_2 (Cayuela et al., 2015). Therefore, the aim of this study was to evaluate the potential of the application of biochar in mitigating N_2O emissions associated with nitrogen fertilizer on crops.

Material and Methods

The study was conducted at the Experimental Station of the Federal University of Parana State (UFPR) in Pinhais - PR. The climate is subtropical humid mesothermal (Cfb), according to Koppen (SIMEPAR, 2015). The soil is classified as Cambisol (Sugamosto, 2002).

The experiment was implemented in December 2015 with the corn planting (Zea mays L.) grown under no-tillage in the straw. The nitrogen fertilizer (urea - $CO(NH_2)_2$) was divided into two applications, 30 kg N ha^{-1} at planting and the rest in coverage (170 kg N ha^{-1}). Each plot was 20 m^2 (4.0 x 5.0 m), with 5 rows of planted corn.

The experimental design was randomized blocks, with five replications allocated in an experimental area with 20 plots (20 m2). The experiment consisted of four nitrogen fertilization treatments in coverage of maize (corn V6 stage) and associated with the application of biochar: A) application of nitrogen fertilizer in the open furrow in the planting spacing (NF); B) application of nitrogen fertilizer to haul (NH); C) application of nitrogen fertilizer mixed with biochar, both in the open furrow in the planting spacing (BNF) and D) application of nitrogen fertilizer mixed with biochar, both haul (BNH) .The biochar applied to the soil is from pyrolysis of wood chips eucalyptus (eucalyptus spp.).

Assessments of emissions started in December 2015, the first just before the planting of corn and the others post-planting. In order to characterize the experimental area, there was gas collection just before the planting of corn (12.08.2015) and after 3, 13 and 46 days, totaling 4 collections. After the treatments (21/01/2016) occurred five collections: 2, 4, 7, 9, 11, 14 and 18 days after that date. Samples of gas were collected applying the method of the static closed chamber taken at times 0, 20, 40 and 60 minutes after closing the chamber. Each collection began at 09:00 am. Emitted gas samples were collected from the corn planting line (L) of separately of the emitted gas from of interlineation (I), allowing the performance evaluation of the gases in function of the location of the treatments in the experimental area. The analyzes of the air samples were by gas phase chromatography by GC equipment - Trace 1310.

Results and Conclusions

The largest N_2O emissions occurred 18 days after treatments (AAT) for all treatments when evaluated in the planting spacing (Figure 1). On this date the soil with BNF showed an emission 21.6 % lower than the soil with NF. However, when the treatment was applied to haul the soil with only nitrogen (317.47 ug m^{-2} h^{-1}) had a lower flow than the soil with biochar (317.47 ug m^{-2} h^{-1}).

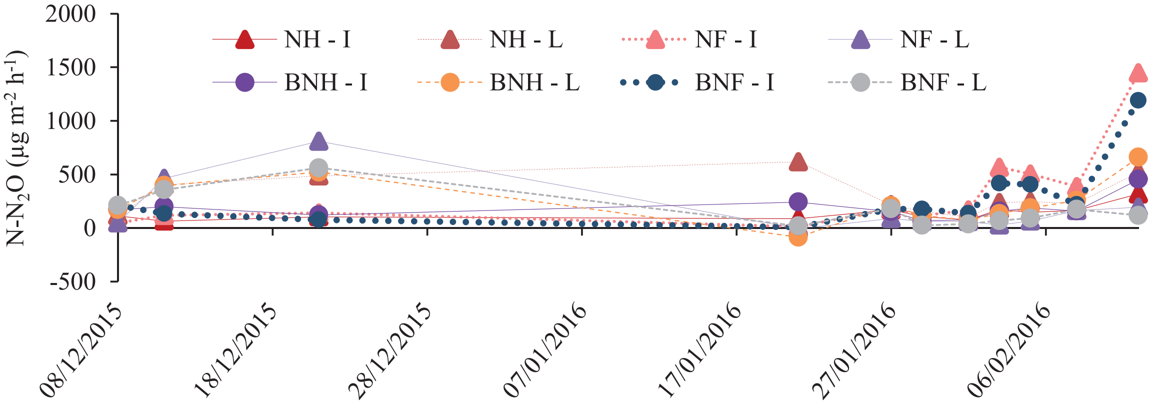

Figure 1. N2O emissions (μg N m^{-2} h^{-1}) on the line (L) and interlineation (I) of planting corn in a Cambisol under application: nitrogen fertilizer in the open furrow in the planting spacing (NF); nitrogen fertilizer to haul (NH); nitrogenous fertilizer mixed with biochar, both in the open furrow in the planting spacing (BNF) and nitrogen fertilizer mixed with biochar, both haul (BNH).

Regarding the evaluations carried out in the row, was observed a peak in emissions of N_2O 13 days after planting (AP) corn (Figure 1). Another rise in flows occurred at 18 days AAT, being the soils with NF and BNF presented a lower emission of this gas. Still, the administration of nitrogenous fertilizer haul associated with biochar resulted in an emission

27.2 % higher in relation to employment just of nitrogen in the soil.

The peak observed only in the evaluations in the planting line to 13 days AP, is due to fertilizer applied at sowing time near the line of planting corn, not influencing emissions in the planting spacing. This effect is commonly observed in post-management period, since it is characterized by an elevation of the mineral nitrogen present in the soil of the previous crop residues and nitrogen fertilization (Zanatta, 2009).

The spatial arrangement of mineral nitrogen in the experimental area was reflected in N_2O fluxes observed. Prior to treatments (topdressing), only in the planting row there was an emission peak in agreement with the absence of fertilizer in the planting spacing. After the treatments, the soil with NS and BNF, had a more significant emission between rows than in the row due to the fact that the treatments were concentrated. As for the NH and BNH treatments the difference between line and line spacing was lower.

The higher spatial proximity of biochar and nitrogen in the soil when applied in the furrow, proved beneficial in helping in mitigating N_2O emissions as a result of their association

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