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Journal of Arid Environments 64 (2006) 137–151

Journal of Arid Environments

www.elsevier.com/locate/jnlabr/yjare

Influence of water regime and N availability on the emission of nitrous oxide and carbon dioxide from tropical, semi-arid soils of Chiapas, Mexico

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Received 22 December 2004; received in revised form 4 May 2005; accepted 5 May 2005
Available online 12 July 2005

Abstract

The concentration of nitrous oxide (N_2O) and carbon dioxide (CO_2) in the atmosphere has increased considerably over the last century, but few studies are available showing their production from soils in semi-arid areas. Soils from the tropical semi-arid Central Depression of Chiapas were sampled from fields cultivated with maize (MAI treatment), under canopy of Acacia angustissima (TIMBRE) or outside the canopy of the trees (OUT), adjusted to 40%, 60%, 80% or 100% of water-holding capacity (WHC) and amended with 0, 15 or 50 mg (NH_4NO_3)-N kg^{-1} dry soil. The production of N_2O, CO_2 and concentrations of NH_4^+, and NO_3^- were monitored in the laboratory under aerobic conditions. Production of N_2O in the first 3 days was significantly larger from the MAI and OUT soils, compared to the TIMBRE soil, while the addition of 50 mg inorganic N doubled the production of N_2O. In all treatments, soil at 100% WHC had the largest production of N_2O. The emission of CO_2 was significantly larger from soils at 60% and 80% WHC compared to the soil at 40% and 100%

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doi:10.1016/j.jaridenv.2005.05.001

WHC, although the addition of inorganic N had no significant effect on CO_2 emission. The application of inorganic N and the absence of vegetation increased the production of N_2O.

Keywords: Acacia angustissima; C mineralization; Cultivation of maize; Natural vegetation; N mineralization

1. Introduction

The concentration of nitrous oxide (N_2O) and carbon dioxide (CO_2) in the atmosphere has increased considerably over the last century and is set to rise further at a rate of approximately 0.4% and 0.25% per year, respectively (IPCC, 1996; Albrecht and Kandji, 2003). Increases in atmospheric CO_2 are mainly due to the use of fossil fuel, industrial activities and changes in soil use, e.g. deforestation (Mestdagh et al., 2002). Nitrous oxide may be produced by several processes (Robertson and Tiedje, 1987), but the principal sources from soils and water are microbial denitrification and nitrification (Yamulki et al., 1995). In the denitrification process N_2O is produced as an intermediate (Conrad, 1996), while in nitrification N_2O is a by-product, released from dissimilatory NO_2^- reduction when O_2 supply is limited, i.e. nitrifier-denitrification (Wrage et al., 2001), or during NH_4^+ oxidation to NO_2^-, i.e. non-denitrifying nitrification (Delwiche, 1981).

Around 25% of the earth's ecosystems are subtropical or semi-arid dominated by nitrogen (N_2) fixing trees of the genera *Acacia* and *Prosopis* (Geesing et al., 2000). The area under the foliage of those N_2-fixing shrub or trees is a refuge for fauna and flora. The trees with there deep roots are capable of reaching water and nutrients that are unavailable for grasses and other plants. Although organic matter accumulates under the canopy of these trees and they cover 31.2 million km^2 the capacity to store carbon (C) in forests of arid and semi-arid areas has not been taken into account in the Global Environment Facility assessment of world C stock (Geesing et al., 2000). Additionally, N_2 fixation increases the nutrient retention by the tree. For instance, East and Felker (1993) found soil under large trees of *Acacia* and *Prosopis* had accumulated 1200 kg ha^{-1} more N than soils outside their canopy. However, few studies have reported on dynamics of greenhouse gases in those ecosystems (Virginia et al., 1982; Lal, 2000; Aulakh et al., 2001; Huang and Chen, 2001; Xu-Ri et al., 2001, 2003).

The Central Depression of Chiapas with an area of 9000 km^2 is tropical and semi-arid. The vegetation was tropical deciduous forest before humans arrived (Breedlove, 1981). Since the introduction of husbandry and agriculture the area is characterized by tropical and subtropical thorn Woodland and Short tree savanna. The agricultural systems in the Central Depression of Chiapas have traditionally received low inputs of inorganic N, but there is a growing tendency to increase application of N fertilizer to maize while deposition of inorganic N is likely to increase with increased urbanization and more intensive husbandry. Little is known