Biological Nitrification Inhibition as a novel approach for Enhancing Nitrogen Use Efficiency in Crops.

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ABSTRACT

Nearly 70% of the applied N fertilizer from managed ecosystems is lost through nitrification and associated processes. The lost N contributes to environmental pollution due to NO_3^- leaching and global warming due to N_2O emission. Additionally, the rising costs of fertilizers are making the crop production more costly than before. For these reasons, Nitrogen use efficiency (NUE) is the key factor in nutrient management for most of the crops. The phenomenon termed as Biological Nitrification Inhibition (BNI) offers an alternative way to enhance NUE in crops as indicated by experiments carried out with *Brachiaria humidicola* at CIAT. A bioassay using a recombinant *Nitrosomonas europaea* strain it was proved that root exudates of this tropical grass can strongly inhibit nitrification. Experiments conducted in the field further confirmed that roots of *Brachiaria* species release BNI compounds in soils. Various tropical grasses with varying degree of BNI activity were selected along with soybean and bare soil, which are believed to lack such BNI capacity, as controls. The soil samples of controls (bare soil and soybean) exhibited the greatest amount of *amoA* genes of Ammonia-Oxidizing Bacteria (AOB) and Ammonia-Oxidizing Archaea (AOA) as compared to soils where *B. humidicola* genotypes were grown. Thus, these results provided a convincing evidence of the occurrence of the BNI phenomenon in the field. The bioluminescence assay and soil chemical measurements have revealed genetic diversity for BNI activities in *Brachiaria* and also in rice genotypes.

KEYWORDS*:* Biological Nitrification Inhibition, *Brachiaria humidicola*, environmental pollution, Nitrogen Use Efficiency, rice, root exudates.

INTRODUCTION

Current global nitrogen fertilizer use has reached approximately 100 million ton N/yr in order to maintain agricultural production (IFA, 2005). Nearly 70% of the applied N fertilizer from managed ecosystems is lost through nitrification and associated processes (Glass, 2003). Agriculture, accounts for nearly 70% of the total anthropogenic emissions of N_2O, a greenhouse gas. Nitrogen use efficiency (NUE) in cereal crop is about 33% (Raun *et al.*, 2002), which is one of the major problems in nutrient management. Novel approaches are essential to complement conventional approaches to identify agronomically superior cereal genotypes that exhibit relatively high NUE. The phenomenon termed as Biological Nitrification Inhibition (BNI) offers an alternative approach to enhance N-uptake and NUE in crops.

METHODOLOGY

A bioassay using a recombinant *Nitrosomonas europaea* strain was developed to quantify the nitrification-inhibition by root exudates of two months old plants that were raised in hydroponics.

A proof of concept work was also carried out at CIAT's field to confirm that roots of *Brachiaria* species release BNI compounds in soils. This field experiment was designed to monitor dynamics of nitrification in soils as influenced by *Brachiaria sp*. with differential BNI capacities. Soybeans and bare soil, which are believed to lack such BNI capacity, were used as controls. A localized application of liquid ammonium-sulfate was applied to each plot. NO_3^- levels in soil and level of *amoA* genes AOB, and –also of AOA were determined to investigate BNI activity under field conditions 1 day after the ammonium-sulfate application.

RESULTS

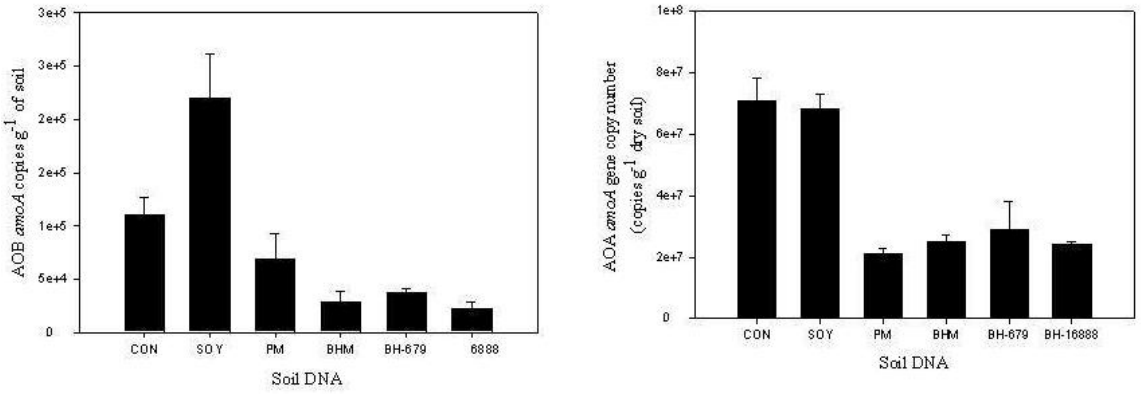

Figure 1. Gene copy number of ammonia-oxidizing bacteria (AOB) *amoA* gene (left), and ammonia-oxidizing Archaea (AOA) *amoA* gene (right) at 1 day after ammonium-sulfate application. CON = control (without any crop); SOY = soybean; PM = *Panicum maximum*; BHM = *Brachiaria* hybrid cv. Mulato; BH-679 = *B. humidicola* CIAT 679 (standard cultivar); BH-16888 = *B. humidicola* accession CIAT 16888 (a high-BNI capacity germplasm accession). Gene copy number was expressed as copy number per g of dried soil and obtained through absolute quantification by using Real-Time PCR.

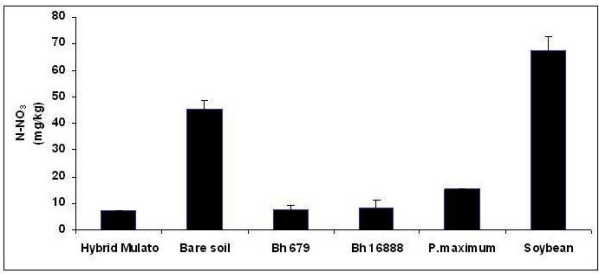

Figure 2. Nitrate (NO_3^-) levels in soil 1 day after fertilization showing BNI activity in *Brachiaria humidicola*.

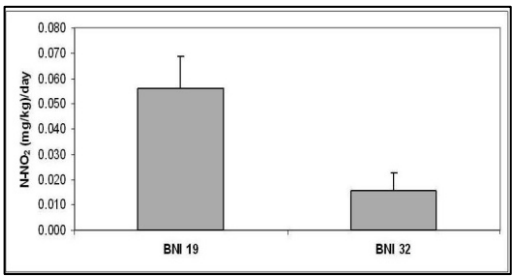

Figure 3. Preliminary evidence of BNI activity of the line BNI 32, an upland rice genotype, by measuring nitrification rate (mg/kg soil/day) in soil.

References

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