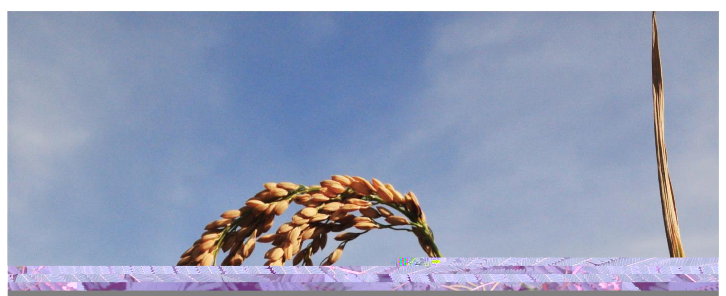
Biological Nitrification Inhibition (BNI)



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Introduction

- The losses of applied nitrogen (N) fertilizer through soil nitrification (oxidation of ammonium (NH_4^+) to nitrate (NO_3^-)) and denitrification have negative socio-economic and environmental impacts.
- Certain plants are able to release chemicals from their roots that inhibit nitrification in the rhizosphere zone, this process is called Biological Nitrification Inhibition (BNI).
- BNI function has been characterized in *Brachiaria humidicola* (Bh), a tropical forage grass that was identified as the species with the greatest BNI activity when compared to other grasses and crops e.g. rice (Tanaka et al., 2010; Sun et al., 2016).
- In this study, the BNI potential of different irrigated, lowland and upland rice germplasm from the CIAT rice program was explored to identify rice cultivar with high BNI potential. Additionally the residual BNI effect of Bh in a simulation of a Bh-rice rotation system for two contrasting soils collected in the piedmont region of the Meta department in Colombia was conducted.

Materials and Methods

For the **evaluation of BNI potential in rice,** 24 materials (varieties, breeding lines and commercial cultivars from both Indica and Japonica) were evaluated using:

- Soil was sampled from the Fedearroz research station at Santa Rosa.
- Two BNI phenotyping methodologies, a bioluminescence assay with the recombinant ammonia-oxidizing bacteria *Nitrosomonas europaea* strain and the incubation of rhizosphere soil for the determination of nitrification rates.

For the **grass-rice rotation study** ("Bh-rice"), three elite upland lines (Line 18, Line 23 and Line 31) were selected from the CIAT/CIRAD breeding program along with a commercial cultivar (C409 "Llanura 11") included as a control check, were evaluated in:

- The soils were collected from the CORPOICA, La Libertad research station. The non-BNI soil "SAR" was sampled in where the CIAT/CIRAD rice breeding program developed the upland rice lines, and the BNI soil "SBH" where Bh CIAT 679 cultivar Tully has been growing for more than 10 years.
- Three N fertilizer treatments 0, 80 and 180 kg.ha^{-1} of N in the form of urea applied three times from 20 to 40 days after planting.
- Rice grain yield was estimated and quantified by the grain weight per pot, expressed in g.pot^{-1} at a humidity of 14%.

Results

In terms of BNI activity of root exudates, determined by bioassay and expressed as allylthiourea units per gram of dry root (ATU g^{-1}), significant differences ($P \leq 0.05$) were identified between rice materials with BNI activity ranging from 3.27 to 31.75 ATU g^{-1}. Soil nitrification rates ranged from 3.06 to 7.63 mg NO_3^--N kg^{-1} soil day^{-1} among rice germplasm (Figure 1), and for lowland rice there was a 50% correlation (r^2=0.52) between the BNI activity of the root exudates and the nitrification rates in soils, meaning that high BNI activity translated in reduced soil nitrification. Yield differences were found between rice lines when grown in different soils and greater yields were observed for the plants grown in the SBH soil (Figure 2).

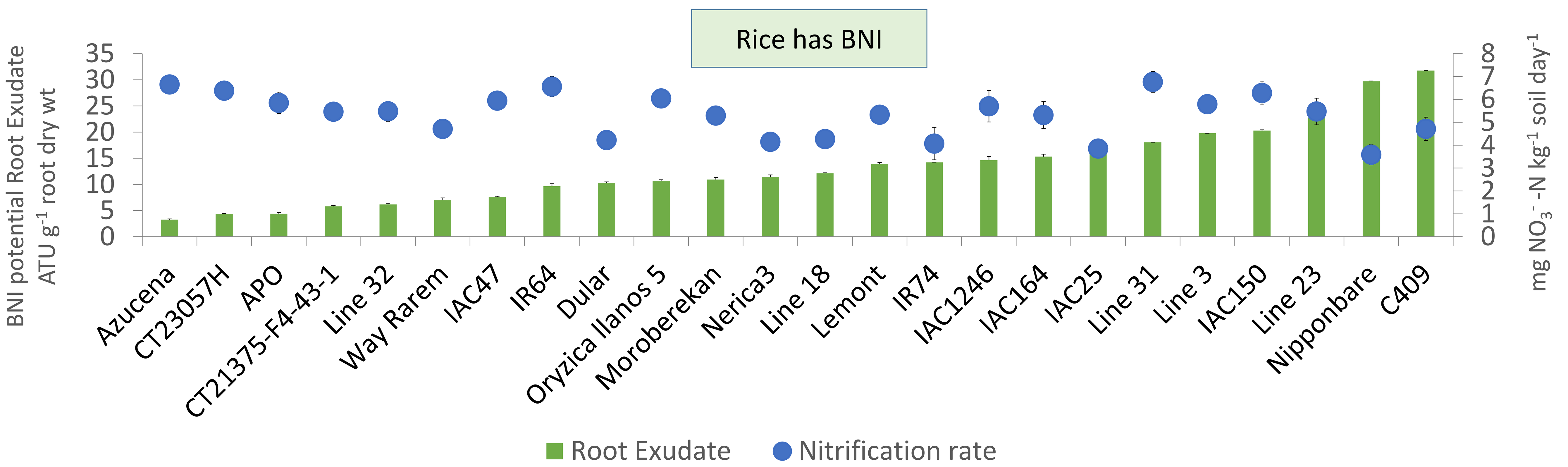

Figure 1. Biological nitrification inhibition (BNI) potential of different rice germplasm estimated with a bioassay using the root exudates and nitrification rates of the soil in experiment with Santa Rosa soil estimated by soil incubation technique. Error bars show standard error of the mean (n = 3).

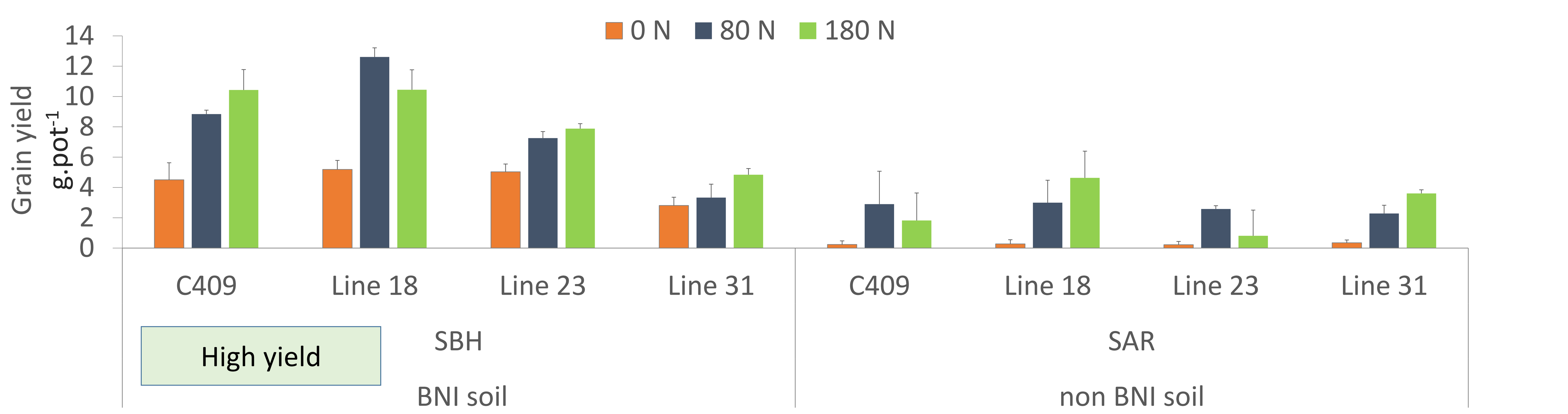

Figure 2. Rice yield expressed as grain weight by pot (in g.pot^{-1}). Different upland rice were scored for yield including elite rice lines from the CIAT/CIRAD breeding program (Line 18, Line 23 and Line 31) and the commercial cultivar C409 to evaluate the benefit of a simulated Bh-rice rotation using soils cultivated with Bh ("SBH" a BNI soil) and rice ("SAR", a non BNI soil). Error bars show standard error of the mean (n = 3).

Conclusions

These results indicate that some rice materials (C409, Line 23, Nipponbare) have the ability to reduce nitrification in soil thanks to the nitrification inhibitory compounds they produce. Also a very promising result is the significant increase in grain yield in a simulated Bh-rice rotation system, with a positive response under no fertilization and a significant increase under treatment with N fertilization for all four upland rice. The Bh-rice rotation system should be further evaluated and implemented in the field to increase rice yields and N use efficiency.

References

Tanaka JP, Nardi P, Wissuwa M (2010) Nitrification inhibition activity, a novel trait in root exudates of rice. AoB Plants 14:1–11

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