Biological Nitrification Inhibition (BNI) in arable plants – a potential for reducing nitrogen losses from agriculture

Marcin W. Skiba[1,2], Timothy S. George[1], Elizabeth M. Baggs[2], Tim J. Daniell[1]

1. The James Hutton Institute, Invergowrie, Dundee, DD2 4DA
2. Institute of Biological and Environmental Sciences, University of Aberdeen, AB24 3UU
Email: Marcin.Skiba@hutton.ac.uk

Introduction

Modern agricultural systems are characterised by large inputs of inorganic nitrogen. The majority of N fertilisers are applied in the form of ammonium. This may cause excessive nitrification with significant losses of N by nitrate leaching and escape of gaseous forms of nitrogen.

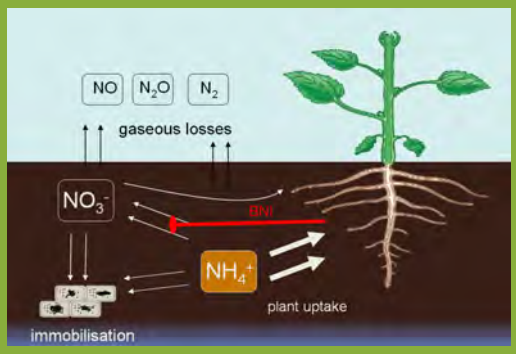

Figure 1 Nitrogen in BNI dominated soil systems. Due to inhibition of nitrification (BNI), ammonium becomes the main form of inorganic nitrogen. N flow is channeled through alternate pathways.

Some plants have the ability to inhibit nitrification in soil. This phenomenon is termed Biological Nitrification Inhibition (BNI). In particular tropical pasture grasses are known to suppress nitrification in soil very effectively. In mature *Brachiaria humidicola* systems where population of nitrifiers is very small, nitrate leaching and nitrous oxide emissions from the soil are greatly reduced (Fig. 1).

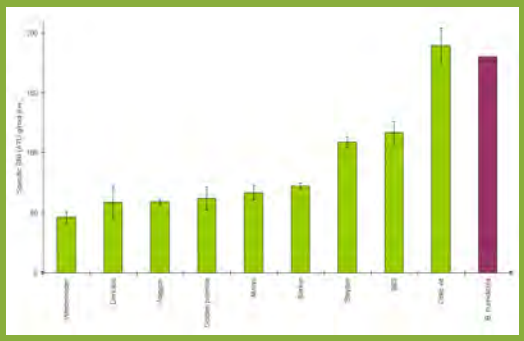

Figure 2 Specific BNI ability of various barley lines compared to previous best *B. humidicola*

Most recently, levels of nitrification inhibition similar to *B. humidicola* have been found in some arable plant species (Fig. 2). This discovery opens the possibility to exploit BNI to improve nitrogen use efficiency and reduce nitrate leaching and gaseous nitrogen emissions from agriculture.

Methods

A range of barley lines expressing variable BNI activity were grown in three different soil types. DNA was extracted from three compartments in soil: bulk soil, rhizosphere and roots. T-RFLP was used to asses differences in community structure of AOB.

In a separate experiment, two contrasting for BNI barley lines, Optic (high) and Bowman (low) were grown in pots with ammonium sulphate as the sole nitrogen source. Gross and net nitrification rates in soil were measured at different stages of plant growth.

Key findings

AOB community structure

We found significant relationship between community structure of AOB and soil type, compartment and barley line. There is a strong correlation between BNI ability of barley and variance in bacterial community structure (Fig. 3).

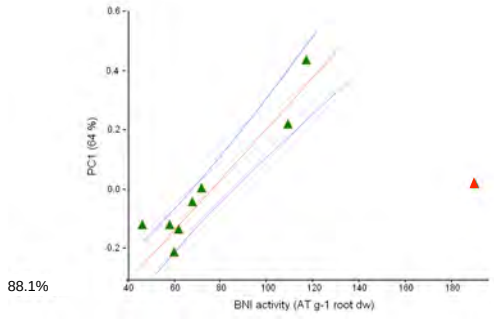

Figure 3 BNI ability of various barley lines grown in Sandy Loam, plotted against Principal Components scores calculated from T-RFLP results. The red data point represents Optic which does not fit well in correlation.

The results suggest that varying BNI ability of barley at least partly explains the dynamics of population structure of ammonium oxidisers. The effect is dependent on soil type.

Nitrification rates

Soil nitrate concentration varied between two barley lines of different BNI ability (Fig. 4). More nitrate was produced in soil with Bowman than Optic.

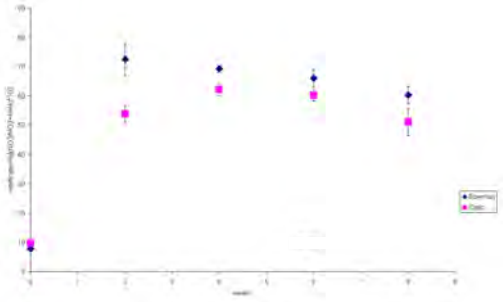

Figure 4 Net nitrification in soil under Optic and Bowman measured at different stages of plant growth.

Gross nitrification rates were no different between two tested barley lines. This can be partly explained by the limitations of the experiment. Further investigation is ongoing.

Summary:

- BNI ability of barley explains the variation in community structure of ammonium oxidisers.
- Some barley lines (Optic) possibly employ different mechanisms to limit nitrification in soil.
- Nitrification rates in soil under high-BNI barley varieties are reduced in comparison to low-BNI lines.

Future work

- Determine the effect of root exudates on nitrogen fluxes in soil using 15-N pool dilution technique in both small scale and field experiments
- Asses the influence of a greater range of barley lines on community structure and size of ammonium oxidisers

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