MORE **BIOLOGICAL NITROGEN STABILISATION** IN ARABLE FARMING

Approximately 20% of the nitrogen applied in agriculture is lost through nitrate leaching – with negative consequences for the environment and the economic efficiency of agricultural businesses. An innovative way to counteract this issue is the strategic use of crop species that release biological nitrification inhibitors (BNI). The corresponding investigation was carried out with the support of the European research project Catch-BNI.

Nitrogen dynamics in the soil

Plants primarily absorb nitrogen in the form of nitrate and ammonium. While ammonium remains bound to soil particles due to its positive charge, negatively charged nitrate is easily washed out. Nitrate dominates in well-aerated arable soils, as the microbial conversion of ammonium to nitrate is particularly rapid there. This often results in more nitrate than the plants can absorb – a risk for the environment and the farm.

For decades, the fertiliser industry has been using synthetic nitrification inhibitors to delay this process. Some crop species are also able to release so-called biological nitrification inhibitors (BNI) via their roots, thereby slowing down nitrate formation in the soil using the same principle of inhibiting the bacteria that convert ammonium into nitrate. These include grasses such as sorghum and maize, cruciferous plants, amaryllis and plantain. By using these in cover crop mixtures and undersown crops, the need for synthetic nitrification inhibitors could be reduced. The EU project Catch-BNI tested this issue for three years.

Catch-BNI (funded by the DFG as part of ERA-NET SusCrop Cofund)

Objective: Optimal N supply for main crops through special cultivation of cover crops.

Phase 1:
Identify crops with BNI effects
→ Results: INNOVATION 02/2023

Phase 2:
Examine influence on N efficiency of summer wheat
→ Testing selected species with BNI effects (white mustard, oil radish, bristle oat and phacelia) as autumn cover crops

Key data on the project can be found in the box on the left. The results are presented below:

Active nitrification inhibition in autumn

In November 2022, all four cover crops (white mustard, oil radish, bristle oat and phacelia) significantly reduced the nitrate concentration in the soil compared to the fallow – in some cases by up to 50% (Fig. 1A, Nov. 2022). Oil radish in particular had an inhibitory effect on the nitrification rate and reduced the amount of ammonium-converting bacteria in the soil (Fig. 1D), although white mustard was considered the strongest BNI candidate in preliminary tests. The results indicate the influence of location, weather and crop development on the BNI effect.

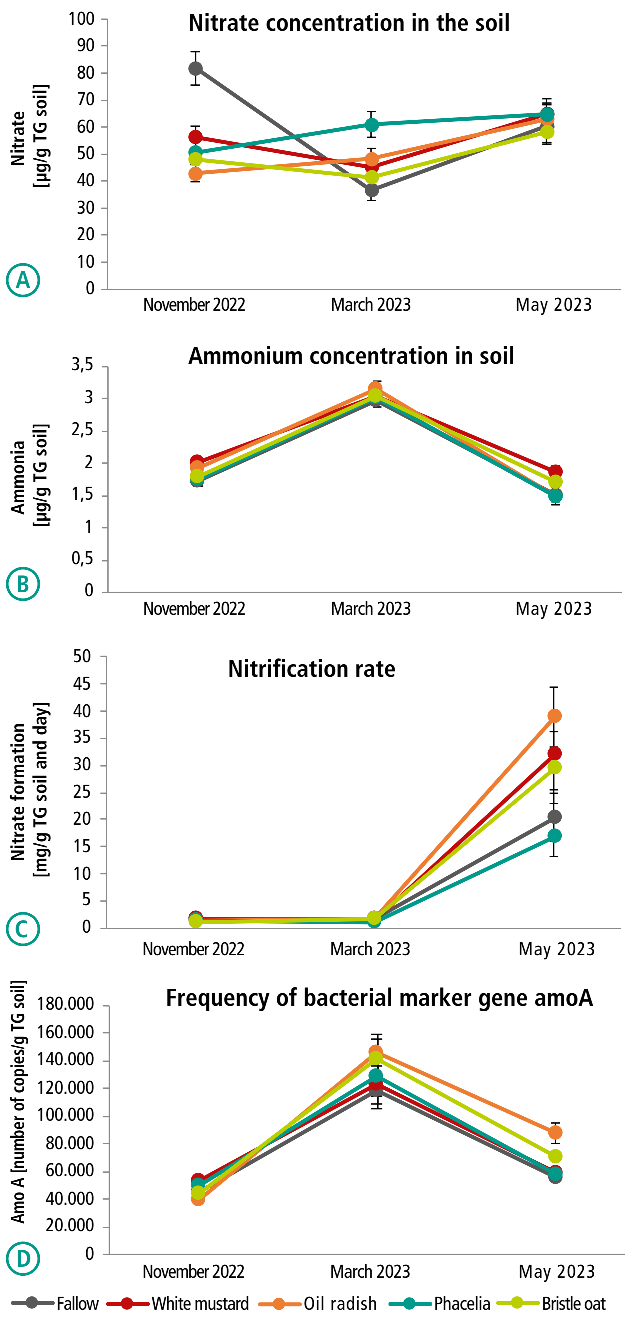
Passive nitrification inhibition in spring

In March 2023, only phacelia and white mustard had a significant inhibitory effect on nitrifying bacteria (Fig. 1D, March 2023). This could be due to their decomposition properties. The biomass of phacelia decomposes largely in spring, as results from the CATCHY project show. This may have contributed to the release of BNI substances in March, while white mustard, which decomposes early in winter (also based on results from the CATCHY project), probably provided little nitrogen for bacterial growth (Fig. 1A). The inhibitory effect persisted in phacelia until May, even under the already established wheat. In contrast, oil radish actually promoted nitrification by 1.5 to 2 times compared to fallow land at that time and thus no longer showed the BNI effect present in autumn (Fig. 1C).

Impact on wheat?

In May 2023, oil radish significantly promoted wheat biomass and nitrogen uptake at the Asendorf site – probably because it released nitrogen early, which was beneficial for the soil at the start of vegetation with the low nitrogen status N_{min} values (~50 kg/ha).

FIG. 1: EFFECT OF BNI COVER CROPS DURING THE VEGETATION PERIOD



(Fig. 1A and 1B) Nitrate and ammonium concentrations on the day of harvest, (Fig. 1C) Nitrate formation after 28 days of dark incubation at 25 °C
(Fig. 1D) Number of copies of the bacterial nitrification marker gene ammonium monooxygenase A (amoA; D) Information on all diagrams: Data collected in field soil under various cover crops during the 2022/2023 growing season. The data were collected in the specified months at the locations Gatersleben (Saxony-Anhalt) and Asendorf (Lower Saxony) and show the mean value +/- standard error with a sample size of 48 (Nov, Mar) and 24 (May), respectively.

HOW CAN THESE RESULTS BE CLASSIFIED?

Results from trials with cover crops in pure seed allow limited statistically validated conclusions to be drawn. Our many years of experience with DSV cover crops and undersown mixtures show that specifically developed mixtures with specific cover crops promote nutrient dynamics and bind nitrogen in the soil. Grasses absorb nitrate, while ribwort plantain inhibits nitrification. Even grass-free maize undersown crops store nutrients for the subsequent crop. Cover crops are therefore already making an active contribution to nutrient dynamics – their value exceeds short-term trial results.

Jan Hendrik Schulz – Product Management Biodiversity

More about CATCHY:

At the trial site in Gatersleben, this trend was less noticeable with N_{min} values of~110 kg/ha. Under nitrogen limited conditions, rapid nitrate availability therefore appears to be more beneficial than a BNI effect for the early development of wheat. Nevertheless, in the end, no significant yield advantage was achieved with any of the cover crop variants. Differences in N_{min}-content after cover crops increasingly levelled out over the vegetation, so that the initial advantage in nitrogen nutrition after oil radish was offset by increased later nitrogen uptake in the other variants.

Conclusion

The Catch-BNI project shows that BNI-active cover crops such as phacelia and oil radish selectively influence nitrogen dynamics, for example by inhibiting nitrification in autumn or delaying nitrogen release in spring. However, there were no lasting or yield-enhancing benefits for the subsequent crop.

Further research has therefore set itself the goal of developing BNI-active undersown crops to ensure continuous nitrification inhibition during the cultivation of the main crop. Results from this project (FertiGO, Green ERA-Hub research framework, BMBF) are expected in 2027.

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