Discovery of biological nitrification inhibitors in maize roots

Nitrogen (N) fertilizer is an essential component for growing most crop plants. However, almost half of the applied N fertilizer is lost from soil as nitrate (NO_3^-, a water pollutant) and as nitrous oxide (N_2O, a greenhouse gas) by two microbial metabolic processes: nitrification and denitrification, respectively. To control agronomic N losses, biological nitrification inhibition (BNI) is a promising strategy. BNI is an ecological phenomenon by which certain plants release bioactive natural products that can suppress nitrifying soil microbes. Our objective in this research is the identification of hydrophobic BNI compounds released from maize roots.

In the search for BNI compounds from the surface extract of maize roots, a new highly BNI active compound was discovered, together with a highly active compound. In addition, two BNI active compounds were identified from the root extract of maize (Fig. 1). The compound with the strongest BNI activity (the ability to suppress nitrification by nitrifying bacteria) was named “zeanone” because it was the first BNI compound to be discovered in nature. The four compounds, including the newly discovered zeanone, were found to have an activity equivalent to 45% of the total BNI activity of maize roots (Table 1). Based on the obtained results, a BNI mechanism in maize is proposed (Fig. 2).

The results of this research are expected to open the way for the construction of eco-friendly agricultural production systems that utilize the BNI-producing ability (BNI capacity) of maize.

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Table 1. Quantity of BNI compounds in maize roots

Compound	Root surface (220 mg)	Root inside DCM extract (395 mg)	Root inside MeOH extract (10 g)	Root (10.615 g)
Zeanone	0.1 mg	0.05 mg	–	0.15 mg (19% of total BNI activity)
HDMBOA	110 mg	132 mg	–	242 mg (20% of total BNI activity)
HMBOA	–	–	3.0 mg	3.0 mg (2% of total BNI activity)
HDMBOA-β-glc	–	–	20 mg	20 mg (4% of total BNI activity)

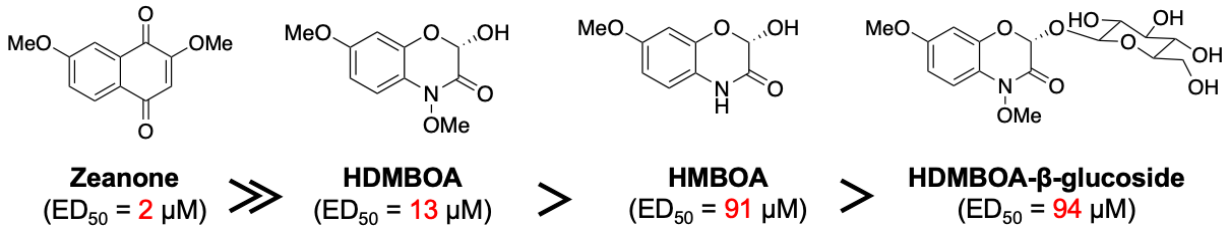

Fig. 1. Structure and BNI activity of BNI compounds

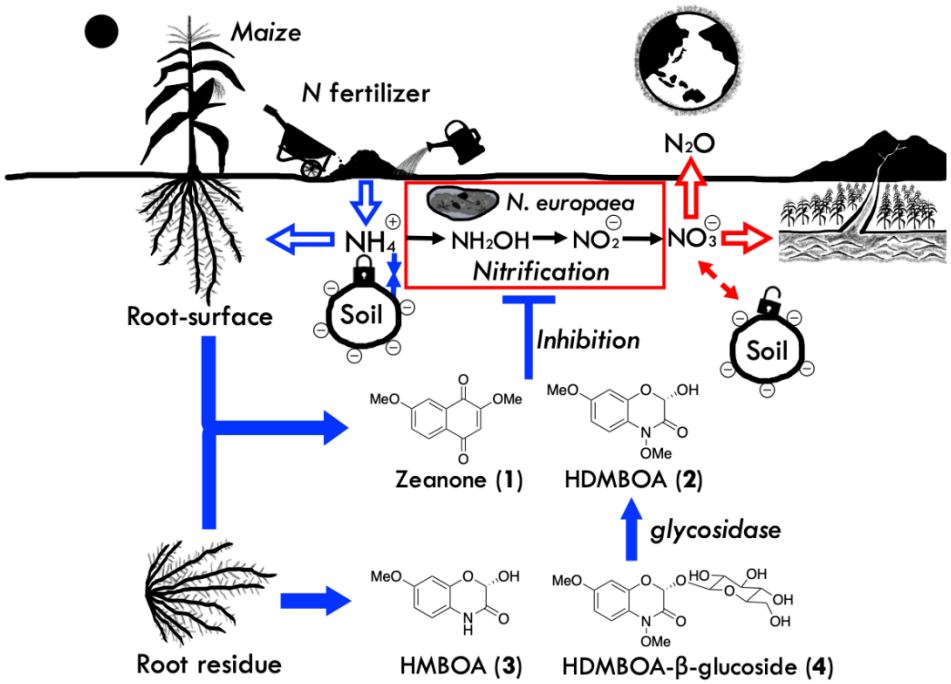

Fig. 2. Proposed BNI mechanism in maize

Reference: Otaka et al. (2021) *Biol Fertil Soils* 58: 251−264, https://doi.org/10.1007/s00374-021-01577-x

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