

Biological nitrification inhibition (BNI)-enabled wheat which maintain the yield with reduced nitrogen fertilizer application

– A case study in South Asian wheat systems

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2022-11-12



Nitrogen cycle of the planet Earth exceeds planetary limit



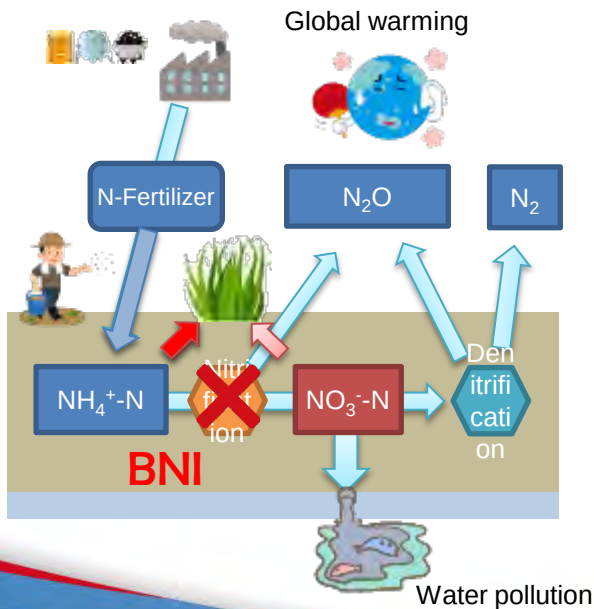
J. von Liebig
"Mineral nutrients" "Liebig's barrel"
(importance of nutrients for production)



Haber-Bosch process
"Making bread from the Air"
(independence from ecosystem)



Norman Borlaug
"The green revolution"
(combination of HYVs and fertilizers)



Planetary Boundaries

after Johan Rockström, Stockholm Resilience Centre et al. 2009

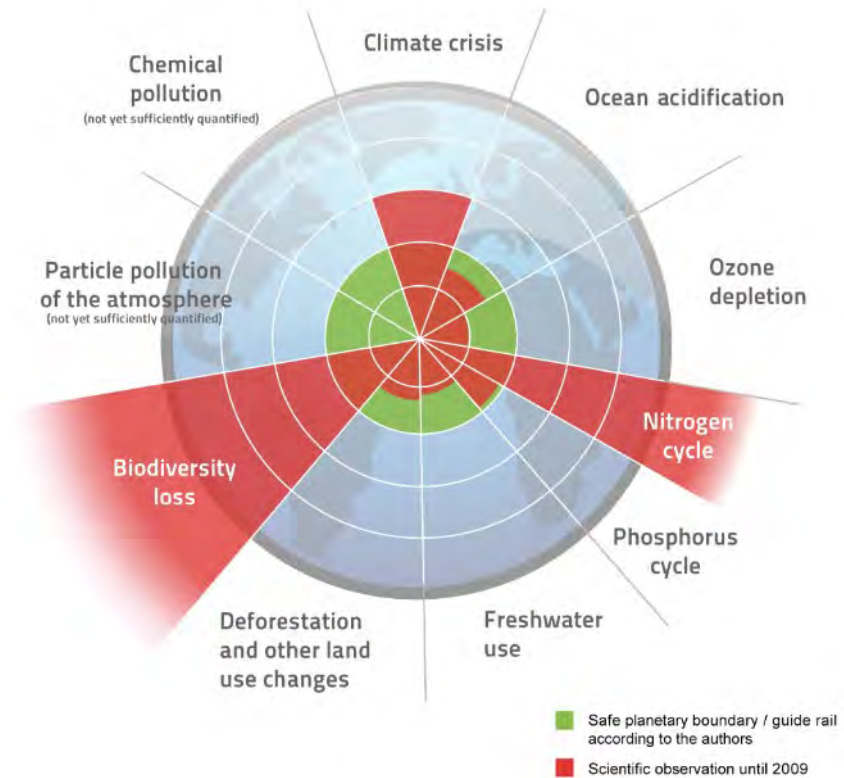
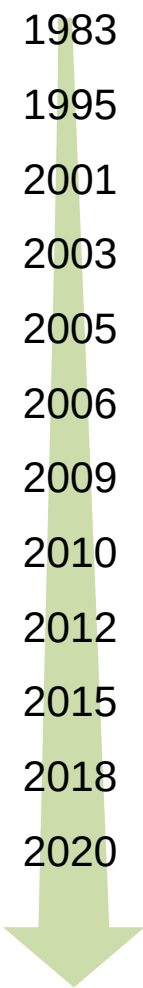


Illustration: Felix Mühlbauer (www.kunft-technologie.de) - license: CC-BY-SA 4.0

Our project aims to improve nitrogen cycle through BNI-technology in wheat to minimize both N-fertilizer application and pollutions caused by excess N application.

Evolution of BNI technology, reach to “proof of concept”

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- 1983 CIAT observed *Brachiaria* pasture soil showing low nitrate level 
- 1995 JIRCAS initiated collaborative research with CIAT in *Brachiaria* pasture
- 2001 Dr. Subbarao joined BNI research 
- 2003 Dr. Subbarao reported soil nitrification inhibition in *Brachiaria* pasture (*Plant and Soil*)
- 2005 1st phase, BNI research project at JIRCAS (2005-10)
- 2006 Introduction of the BNI concept for further crop development (*Critical Reviews in Plant Sci.*)
- 2009 Confirmation of BNI in *Brachiaria* pasture (*PNAS*) 
- 2010 2nd phase, BNI research project (2010-15), initiating sorghum BNI with ICRISAT
- 2012 Confirmation of BNI in sorghum (*Plant and Soil*)
- 2015 3rd phase, BNI research project (2015-20), initiating wheat BNI with CIMMYT
- 2018 Initiating maize BNI, and obtaining several BNI compounds (*Biology and Fertility of Soil*)
- 2020 Confirmation of BNI effect in BNI-enabled elite wheat lines at field level

Proof of concept

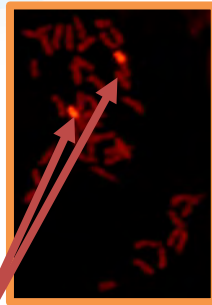
The story is going on....

Development of BNI-enabled elite wheats

May 2020: Tsukuba, Japan

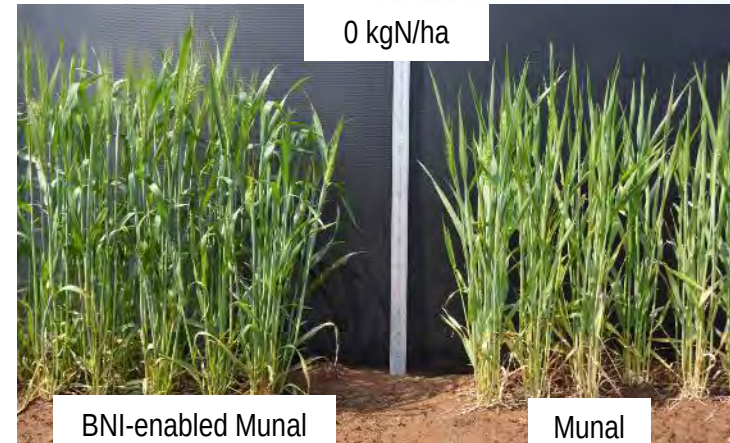


Leymus racemosus

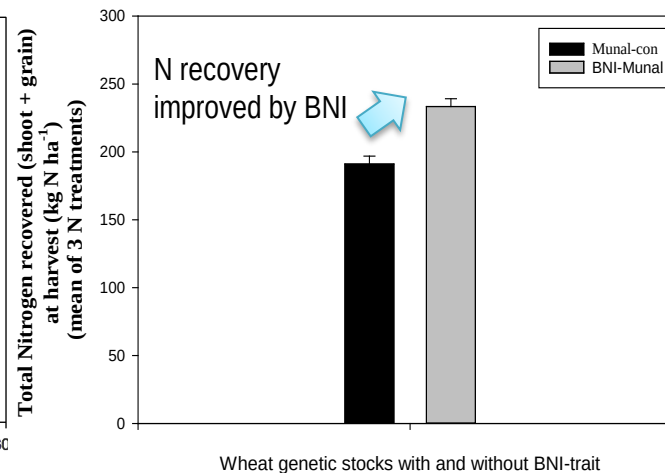
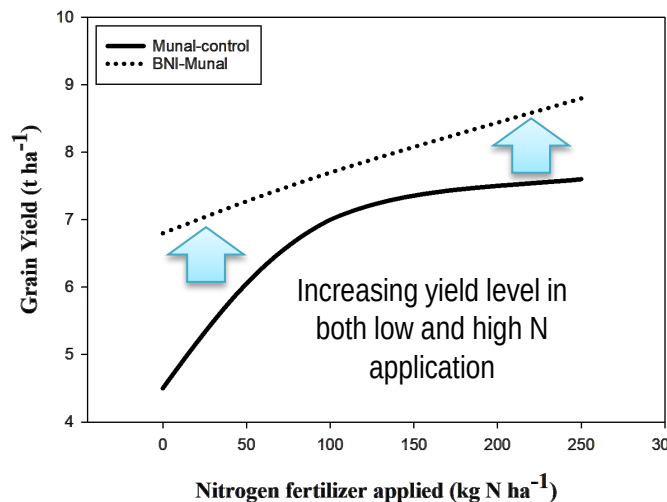


n chromosome short arm (Lr#n) holds BNI capacity.

Lr#n introduction to international elite wheat line based on conventional crossing



Visible impact of BNI was observed!

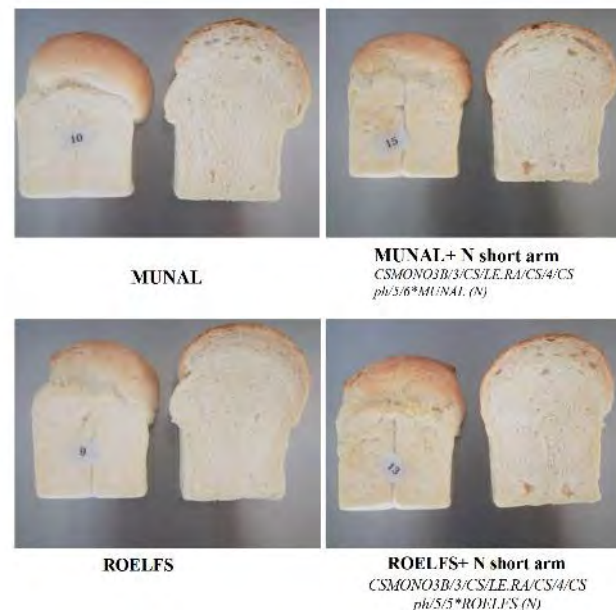


Effect of BNI-trait was confirmed.

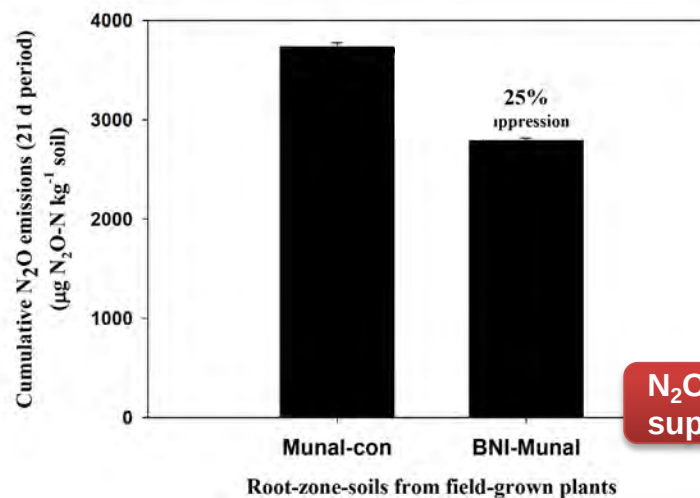
Benefit of BNI-enabled wheat



BNI-enabled wheat utilizes nitrogen more efficiently



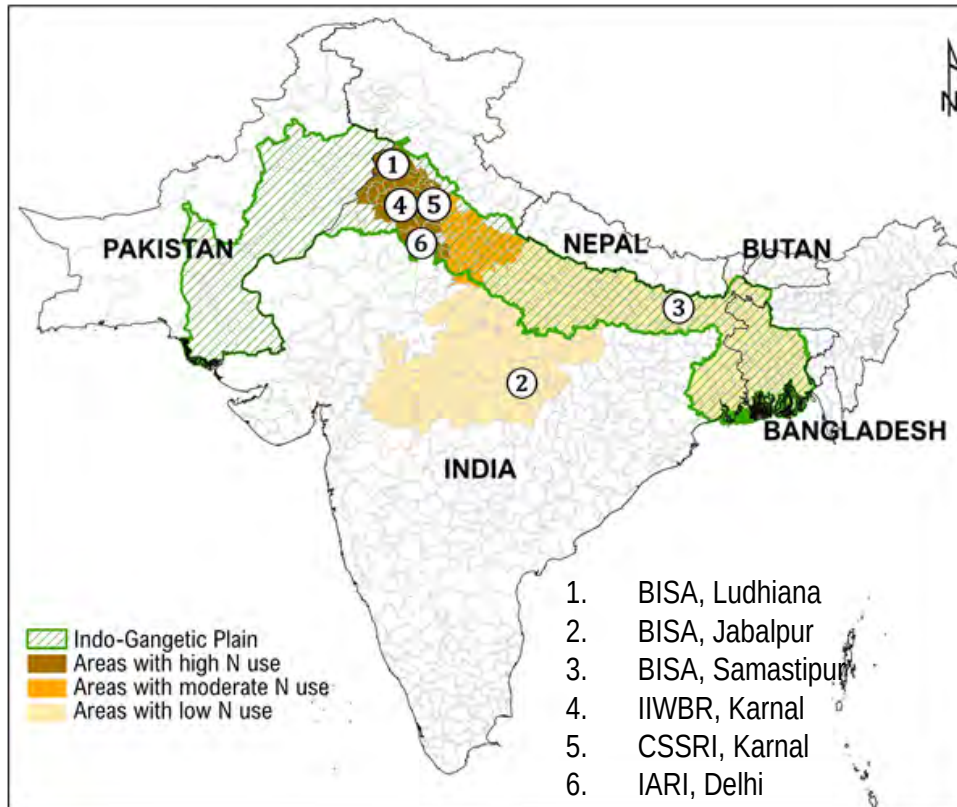
No penalty for grain quality



N₂O emission from soil suppressed

Indo-Gangetic Planes, the focal point of our project

N application in IGP and project sites



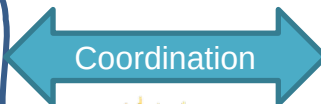
Courtesy: BISA

- Food basket of world 2nd largest wheat producing country, India
- 80% of wheat production is in IGP
- Success of the Green revolution in India praised here
- NW zone, Panjab and Haryana applies higher N application than other area
- NUE in the area is considered about around 3-40%
- ❑ Around 20% of production cost is come from fertilizer cost
- ❑ N fertilizer is considered as a possible source of environmental pollutions



There is a need for
“climate-smart agriculture”

The Project for Establishment of Nitrogen-efficient Wheat Production Systems in Indo-Gangetic Plains by Deployment of BNI-technology



JIRCAS

- Management
- Introduction of BNI into Indian elite lines
- Exploring BNI substances in BNI-Wheat



CIMMYT

- Introduction of Lr#n into Indian elite lines



NARO, Hokkaido

- Confirmation of Lr#n transfer by PCR maker



Tottori Univ.

- Arid Land Research Center
- BNI gene discovery in Lr#n

High NUE wheat by BNI

1. BNI-enabled Indian elite lines
2. BNI-enabled international elite lines
3. Screening for local BNI materials
4. BNI Gene discovery in Lr#n
5. BNI compounds for Lr#n
6. Nitrogen cycling in designated field
7. Multilocation tests for deployment



Borlaug Institute for South Asia

- Management for Indian-side
- Multilocation tests for BNI-Wheat lines



Indian Institute of Wheat and Barley Research

- Materials for BNI exploration
- Dissemination through AICRP-W&B activities

AICRP-Wheat & Barley

- Platform for all Indian wheat improvement



Indian Agricultural Research Institute

- Exploring BNI genes
- Detailed field test for BNI impact



Central Soil Salinity Research Institute

- Detailed research to clarify the impact of BNI wheat in soil

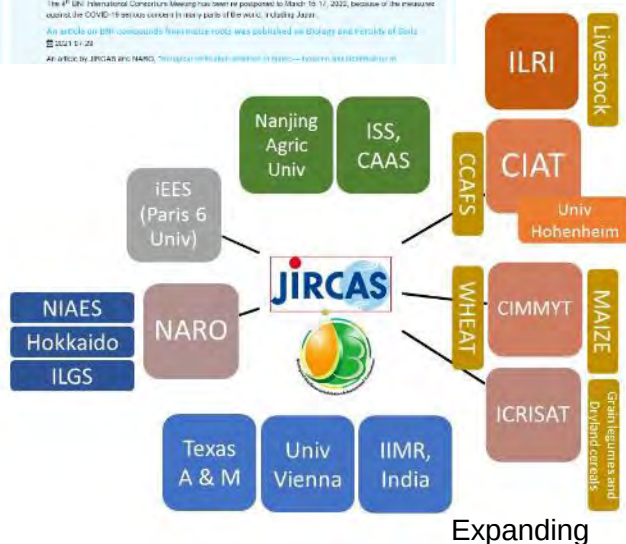


JIRCAS's activities on BNI technology



- JIRCAS formulated “**BNI International Consortium**” with various institutes together with CGIAR centers.
- We organize biannual meeting of the consortium and expected to have 4th meeting on Mar 2022 at Tsukuba, Japan.
https://www.jircas.go.jp/en/program/program_a/bni

- JIRCAS has own research project on BNI, “Development of planet-friendly agricultural production system using biological nitrification inhibition (BNI) technology”. Besides wheat, we are dealing with maize, sorghum and *Brachiaria* pasture to develop planet-friendly production system.



Wheat



Maize

CIMMYT
International Maize and Wheat Improvement Center



Sorghum

ICRISAT
International Crops Research Institute for the Semi-Arid Tropics



Brachiaria

CIAT
International Center for Tropical Agriculture

ご清聴
ありがとうございました



www.jircas.go.jp