EuroChem Group

Global R&D Premium Products

Effects of the novel nitrification inhibitor DMPSA on yield, mineral N dynamics and N_2O emissions

Andreas Pacholski[1], Nils Berger[1], Ivan Bustamante[2], Rainer Ruser[2], Guillermo Guardia[3], Thomas Mannheim[1]

1 EurochemAgro GmbH, Germany, Andreas.pacholski@eurochemgroup.com
2 Hohenheim University, Germany
3 Universidad Politecnico de Madrid, Spain

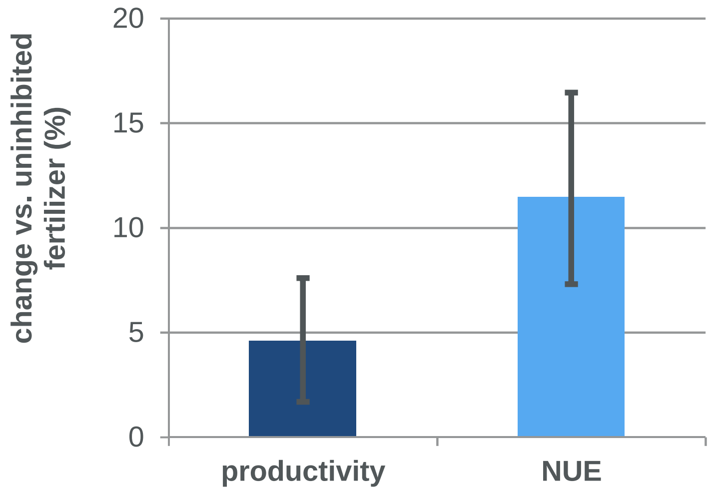
Agenda

1. Nitirification inhibitors – relevance for crop production and environment
2. The novel inhibitor DMPSA
3. Agroecological and yield trials trials
4. Results and discussion
   - Agroecological trials: yields, N_2O emissions, GHG footprint
   - Yield trials: yields and NUE
5. Summary and outlook

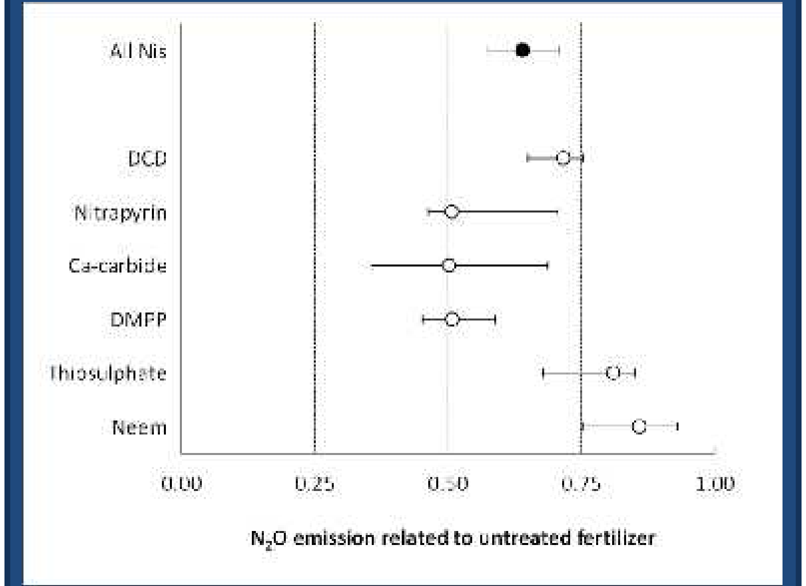
The role for nitrification inhibitors in agronomy

- Stabilizing ammonium in ammonium and amid based fertilizers
- Thereby
  - safeguarding and increasing N availiabilty, yields and NUE
  - Reducing nitrate leaching and N_2O emissions

Effect of nitrification inhibitors on productivity and NUE (Abalos et al. 2014)



Effect of nitrification inhibitors on emisson of GHG N_2O (Akiyama et al. 2010)



Introduction

Experimental Designs

Results Agro-ecological trials

Results Yield monitoring

Summary + Outlook

The novel nitrification inhibitor DMPSA

- DMPSA = isomeric mixture of 2-(3,4-**dimethylpyrazol**-1-yl)-succinic acid and 2-(4,5- dimethylpyrazol-1yl)-**succinic acid**
- Active ingredient: DMP similar as in DMPP
- and
  - Longer lasting release curve of DMP compared to DMPP
  - Applicability on all amid and ammonium based fertilizers yet not inhibited by NI (e.g. CAN, DAP etc.)

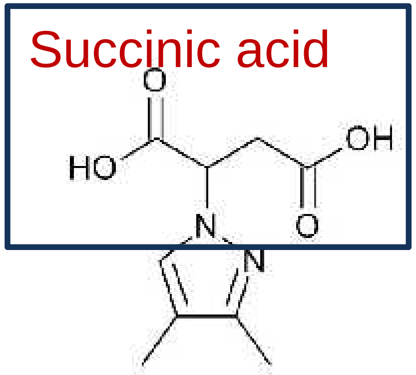
Introduction

Experimental Designs

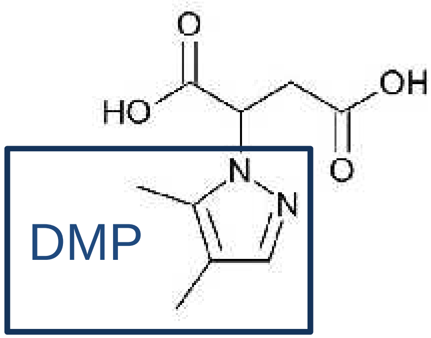
Results Agro-ecological trials

Results Yield monitoring

Summary + Outlook



2-(3,4-dimethyl-1H-pyrazol-1-yl)succinic acid



2-(4,5-dimethyl-1H-pyrazol-1-yl)succinic acid

Effects of DMPSA on yields and GHG emissions Spanish maize

(Guillermo Guardia, Sonia Garcia-Marco, Antonio Vallejo)

years: 2014+15

- 28% clay, 17% silt, and 55% sand, pH 7.6, all basic nutrients balanced

- Treatments (all at 180 kg N/ha as top dressing)

complete randomized block design:

i) Calcium Ammonium Nitrate (**CAN**);

ii) CAN + DMPSA (**CAN+NI**);

iii) Control with no N fertilizers (**CK**)

- Irrigation: sprinkler, 705 mm (44 events) + 151 mm rain

Experimental design irrigated maize study

(Guillermo Guardia, Sonia Garcia-Marco, Antonio Vallejo)

Gas measurements:

- Gas species (N_2O, CH_4, CO_2 (GC); NO (chemoluminiscence)
- Static chamber method (2 samplings, t1 = 0, t2 = 60 min)
- 2 measurements/week first month after fertilization, later on less

Maize harvest: 0-0.1 m (3 cores/plot), harvest at black line stage (14% water content) + elemental analysis

Experimental design irrigated maize study

(Guillermo Guardia, Sonia Garcia-Marco, Antonio Vallejo)

- ^{15}**N study**: 2 (1 m x 1 m)-subplots within plots, with labeled NH_4^+ OR NO_3^-, closed chamber

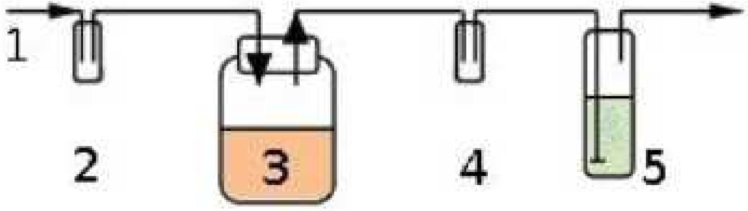
Plot (7m x 6.5m)	Microplot (1m x 1m)		
fertilizer	Treatment applied	Designation	N rate (kg N ha^{-1})
CAN	$^{15}NH_4NO_3 + NH_4NO_3$	^{15}AN	90 + 90
	$NH_4{}^{15}NO_3 + NH_4NO_3$	A^{15}N	90 + 90
CAN+DMPSA	$^{15}NH_4NO_3 + NH_4NO_3$ + DMPSA	^{15}AN+NI	90 + 90
	$NH_4{}^{15}NO_3 + NH_4NO_3$ + DMPSA	A^{15}N+NI	90 + 90

Incubation trial in Germany

(Bustamante, Ruser)

- Soil incubation in glass vessels
- Measurement of soil mineral N (NH_4^+, NO_3^-) and N_2O emissions
- Incubation time 28 days
- Application rate corresponds 200 kg urea N/ha = 0.51 mg N/ g soil
- Silt loam, pH 6.8, 20 °C

Experimental setup



1. Air inlet
2. Gas sample inlet air
3. Glass bottle
(250 ml, 150 g soil)
4. Gas sample outlet air (N_2O)
5. Acid trap for NH_3-sampling

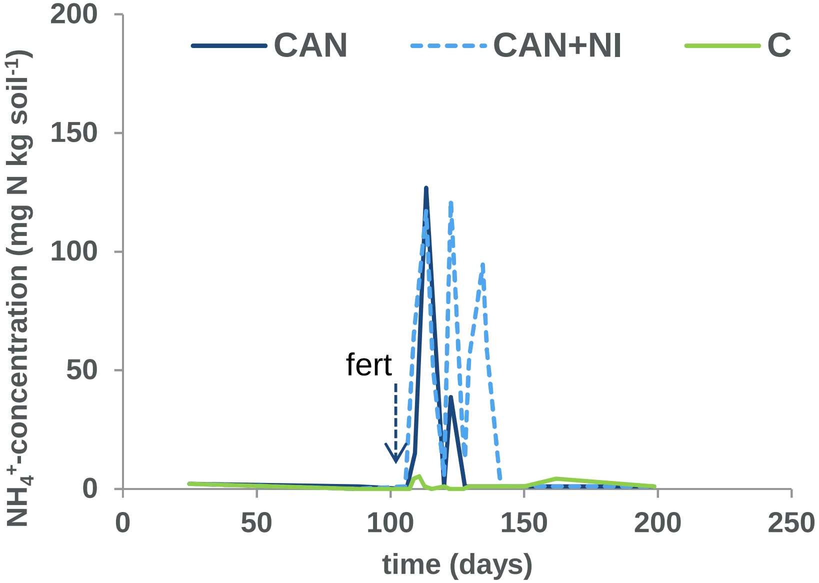
Yield monitoring trials

- Replicated multi-plot field trials
- Yield + NUE (cereals)
- Carried out by external trial providers
- European and Non-European Countries
- Vegetables, broad acre crops + fruits
- DMPSA inhibited product vs. respective uninhibited fertilizer
- Farmers' practice fertilization levels

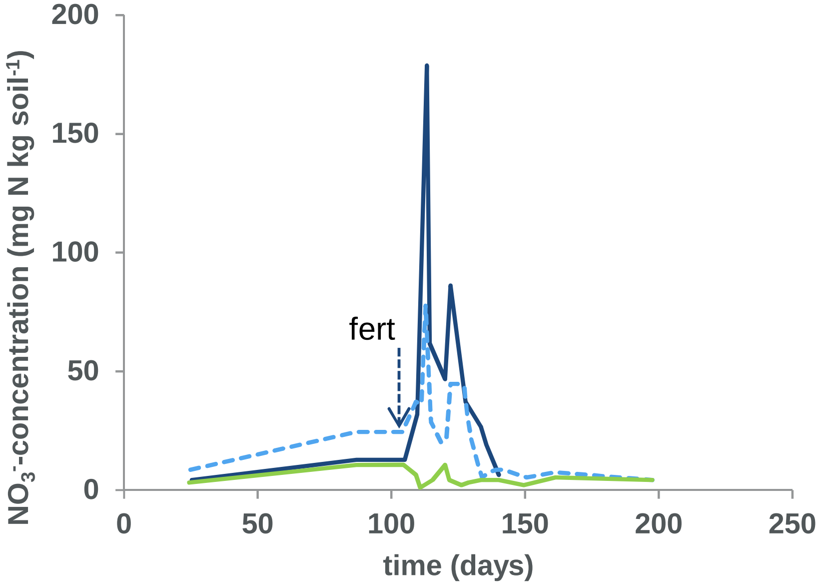
Field trials Spain: nitrate + ammonium concentrations in surface soil

(Guillermo Guardia, Sonia Garcia-Marco, Antonio Vallejo)

ammonium



nitrate

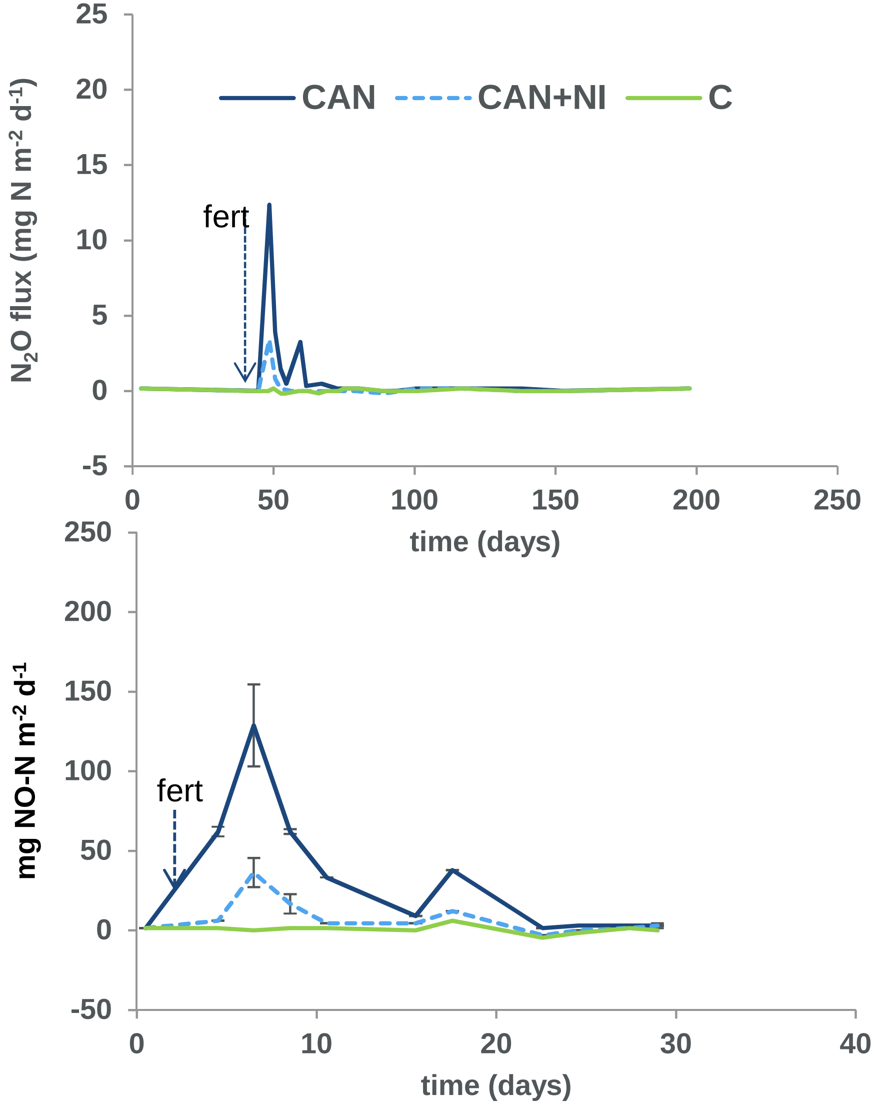


Field trials Spain: N_2O + NO emissions

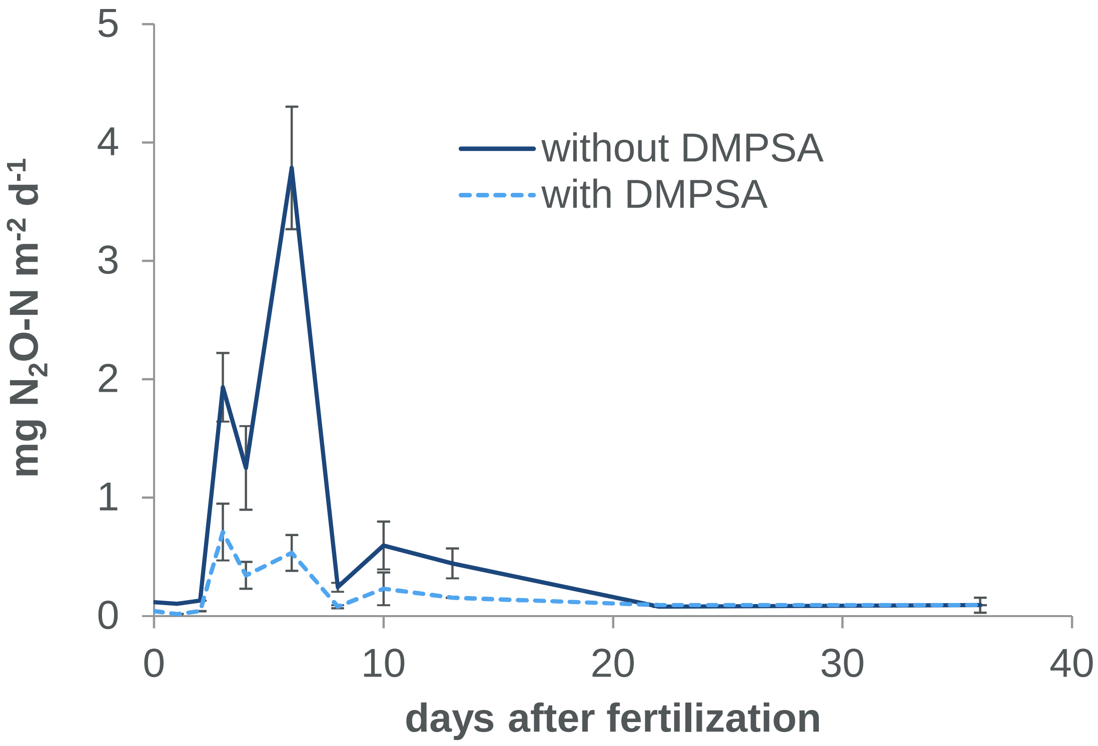
(Guillermo Guardia, Sonia Garcia-Marco, Antonio Vallejo)

N_2O

NO



Field trials Spain: N_2O emissions ^{15}N microplots



Field trial Spain: N_2O emissions ^{15}N microplots

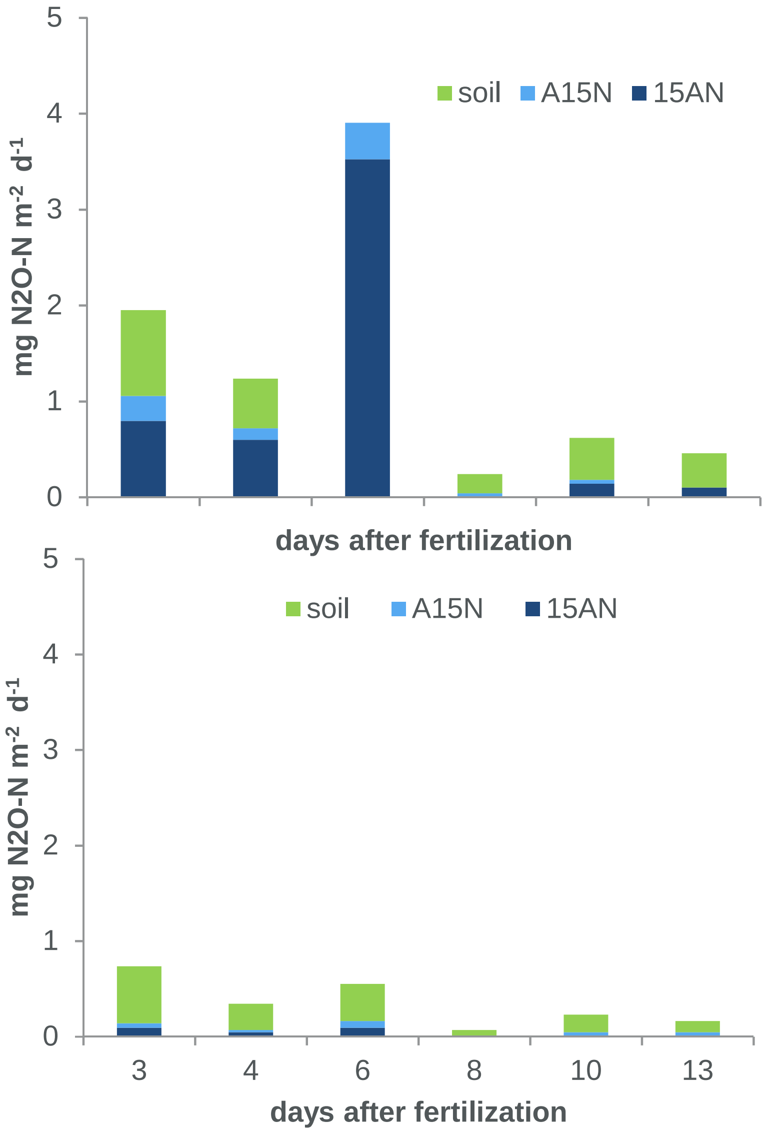
(Guillermo Guardia, Sonia Garcia-Marco, Antonio Vallejo)

N sources of N_2O emissions

Without DMPSA

A15N = source NO_3^-
15AN = source NH_4^+
soil = source orig. soil N

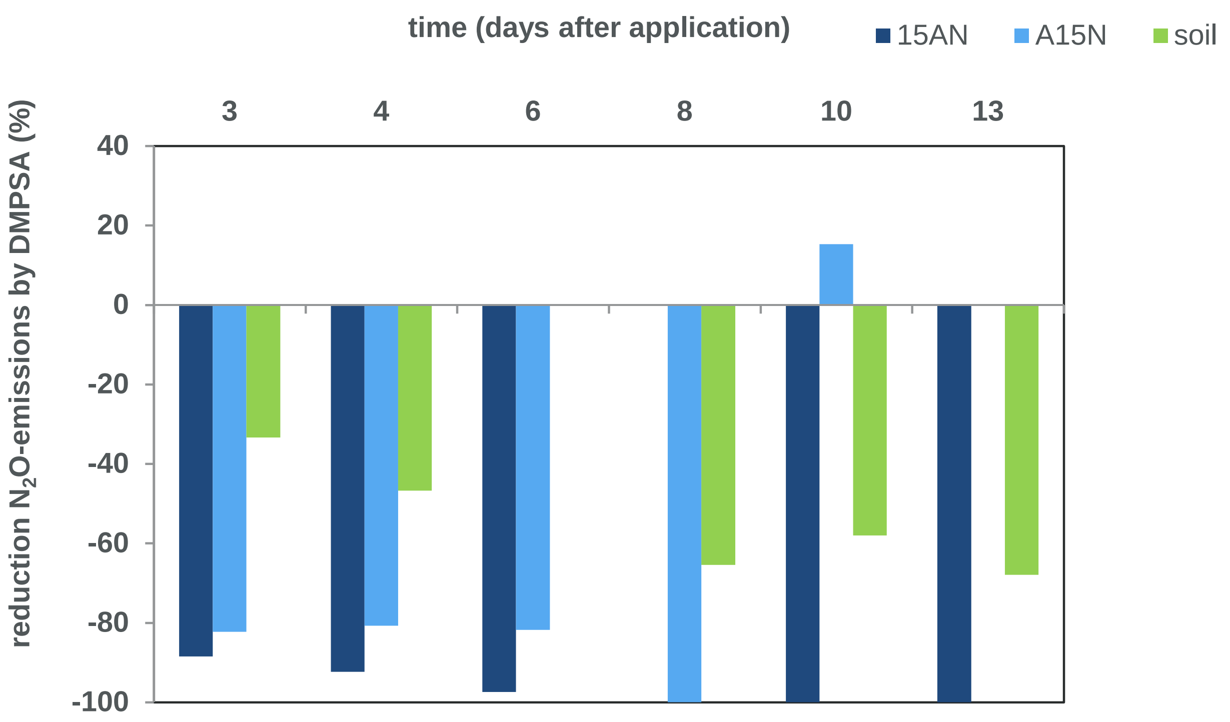
With DMPSA



Field trial Spain: Reduction of N_2O emissions ^{15}N microplots by N sources of emissions

(Guillermo Guardia, Sonia Garcia-Marco, Antonio Vallejo)

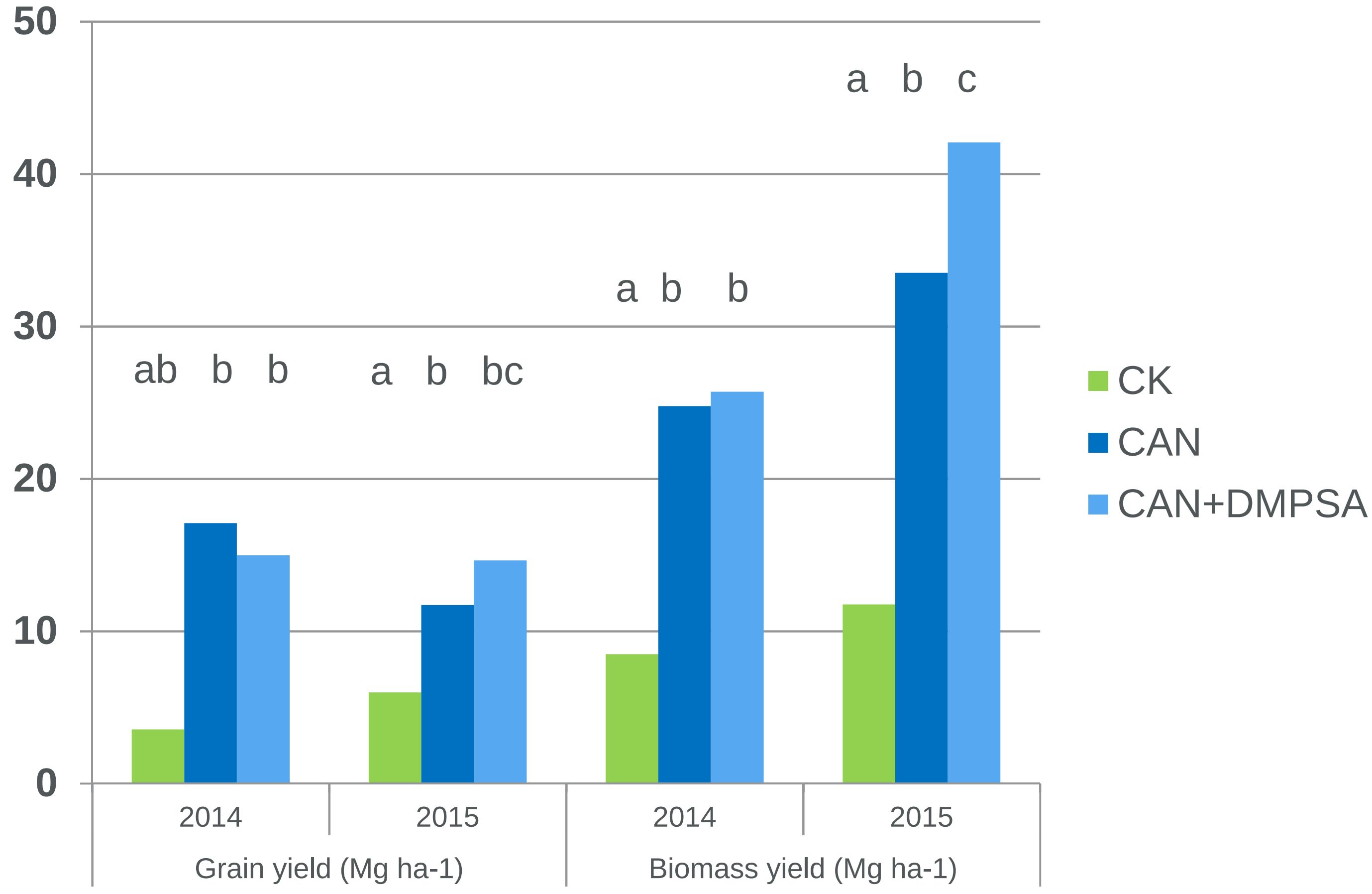
– reduction also from original nitrate N



$A^{15}N$ = source NO_3^-
^{15}AN = source NH_4^+
soil = source orig. soil N

Field trial spain: corn grain and biomass yield

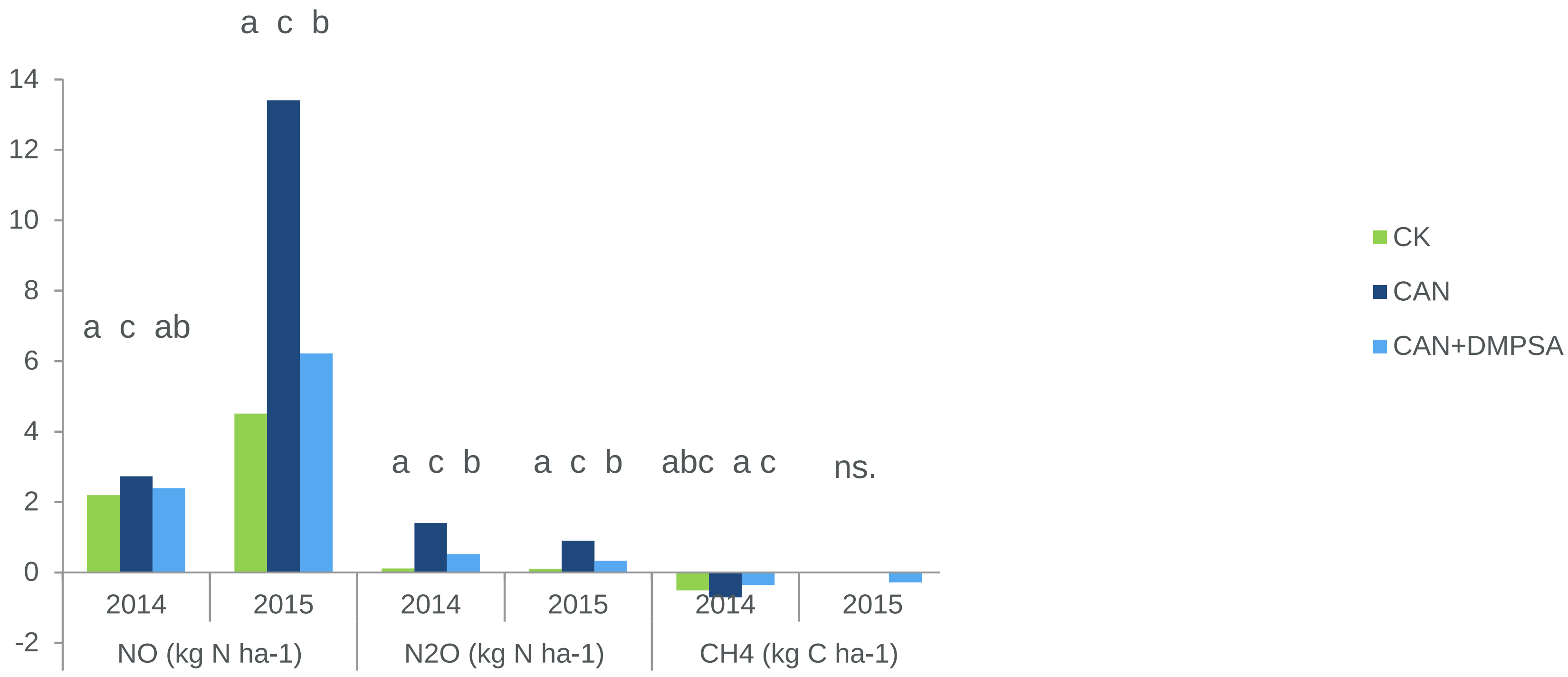
(Guillermo Guardia, Sonia Garcia-Marco, Antonio Vallejo)



S.E.	**0.15**	**1.99**	**0.24**	**2.77**
P value	0.000	0.024	0.001	0.000

Field trial Spain: Trace gas emissions

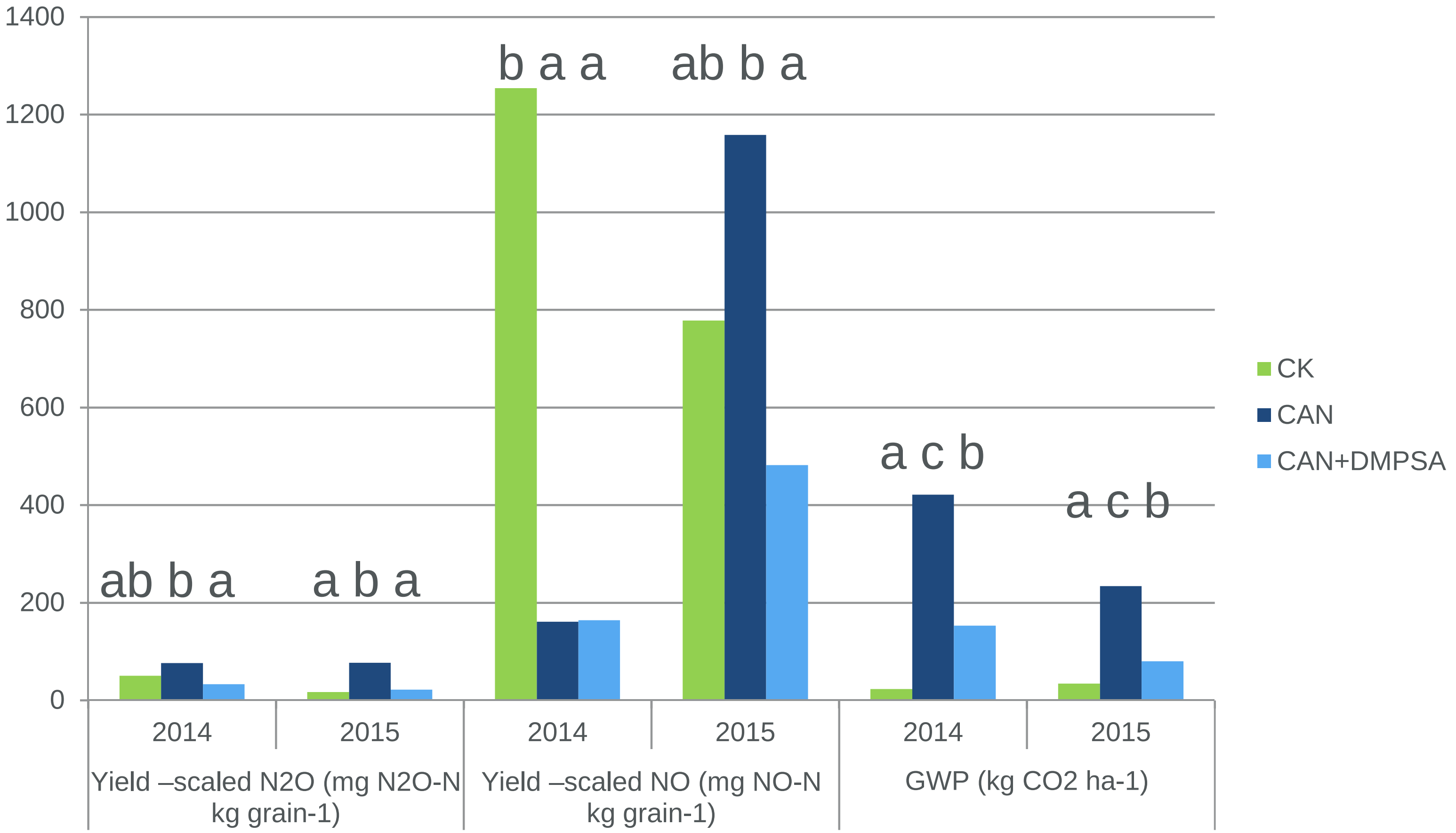
(Guillermo Guardia, Sonia Garcia-Marco, Antonio Vallejo)



S.E.	0.09	1.10	0.12	0.14	0.06	0.08
P value	0.019	0.000	0.000	0.000	0.024	0.583

Field trial Spain: yield scaled emissions

(Guillermo Guardia, Sonia Garcia-Marco, Antonio Vallejo)



S.E.	12	14	325	488	39	38
P value	0.086	0.000	0.134	0.070	0.000	0.000

Introduction

Experimental Designs

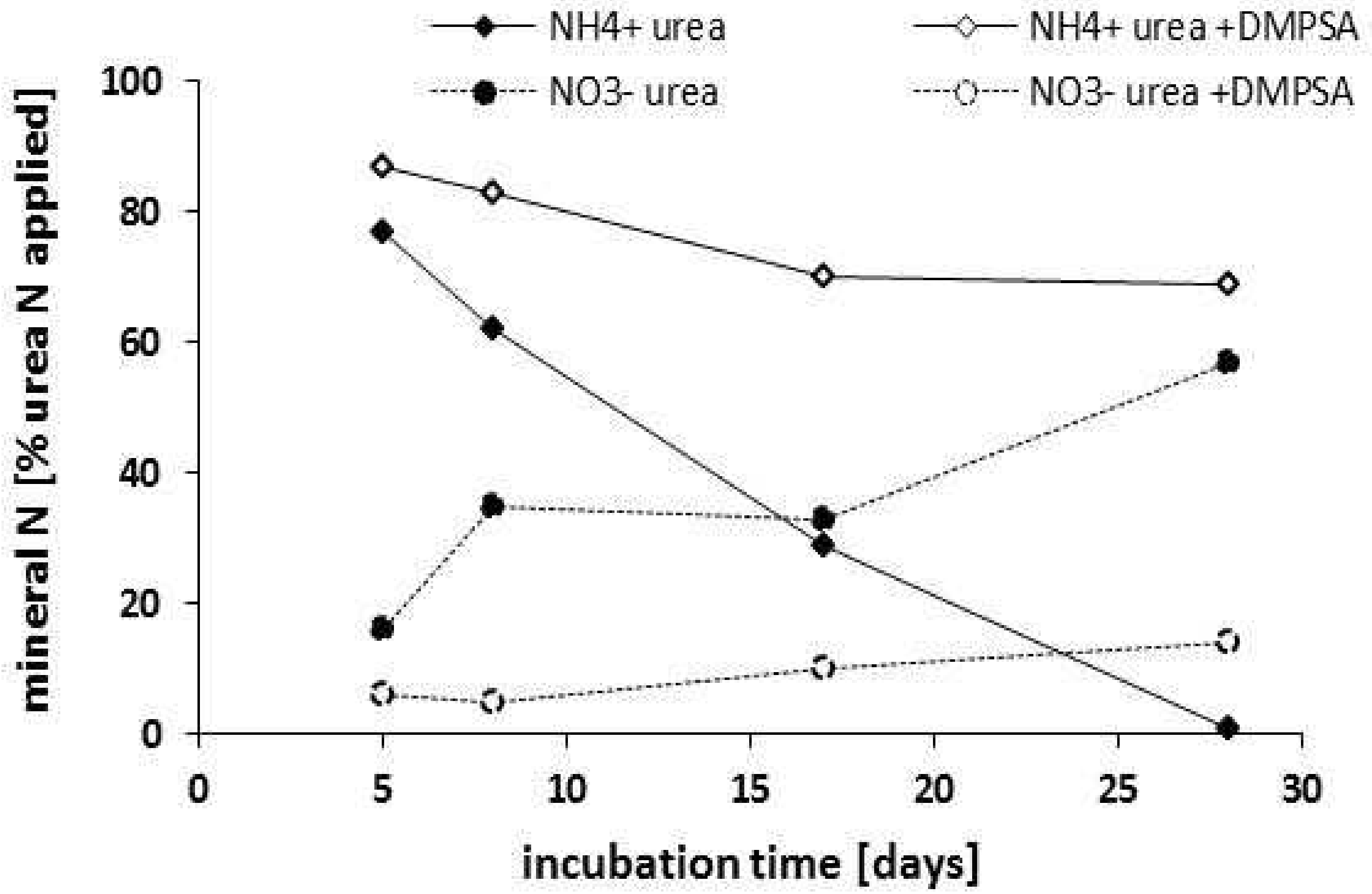
Results Agro-ecological trials

Results Yield monitoring

Summary + Outlook

Urea + DMPSA in **incubation trial**: mineral N dynamics

(Bustamante, Ruser)



Introduction

Experimental Designs

Results Agro-ecological trials

Results
Yield monitoring

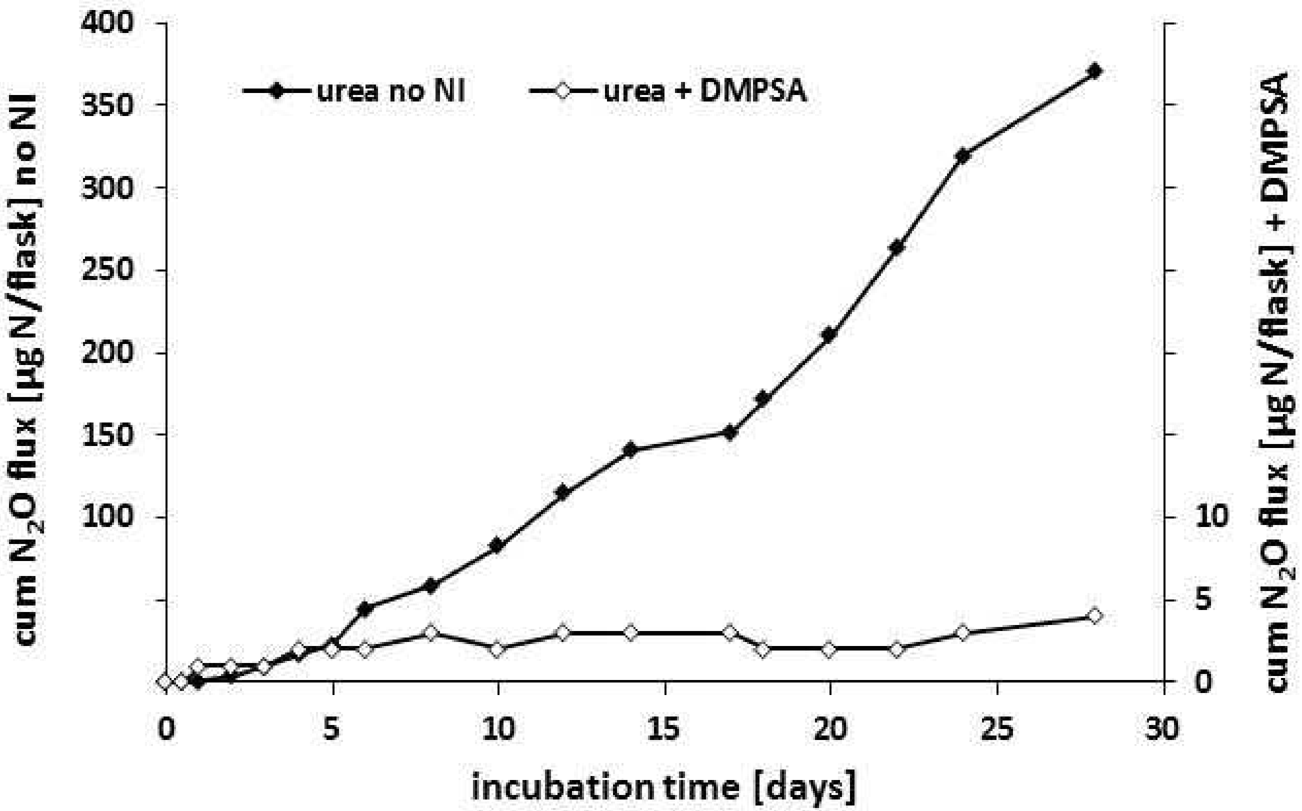
Summary + Outlook

Long lasting stabilization of ammonium

Urea + DMPSA in **incubation trial**: cumulative N_2O emissions

(Bustamante, Ruser)

Redution of N_2O emissions by almost 100%



Introduction

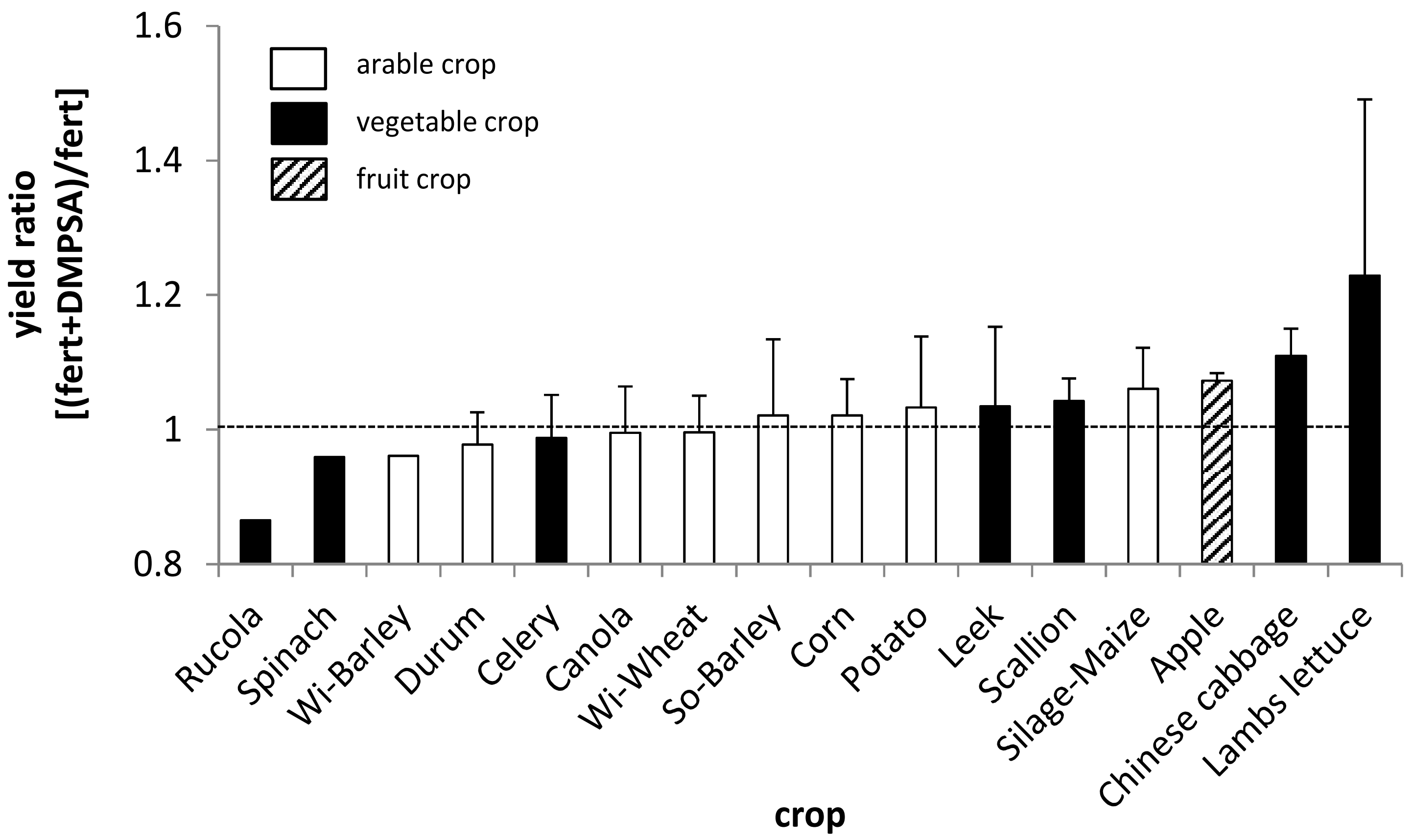
Experimental Designs

Results Agro-ecological trials

Results
Yield monitoring

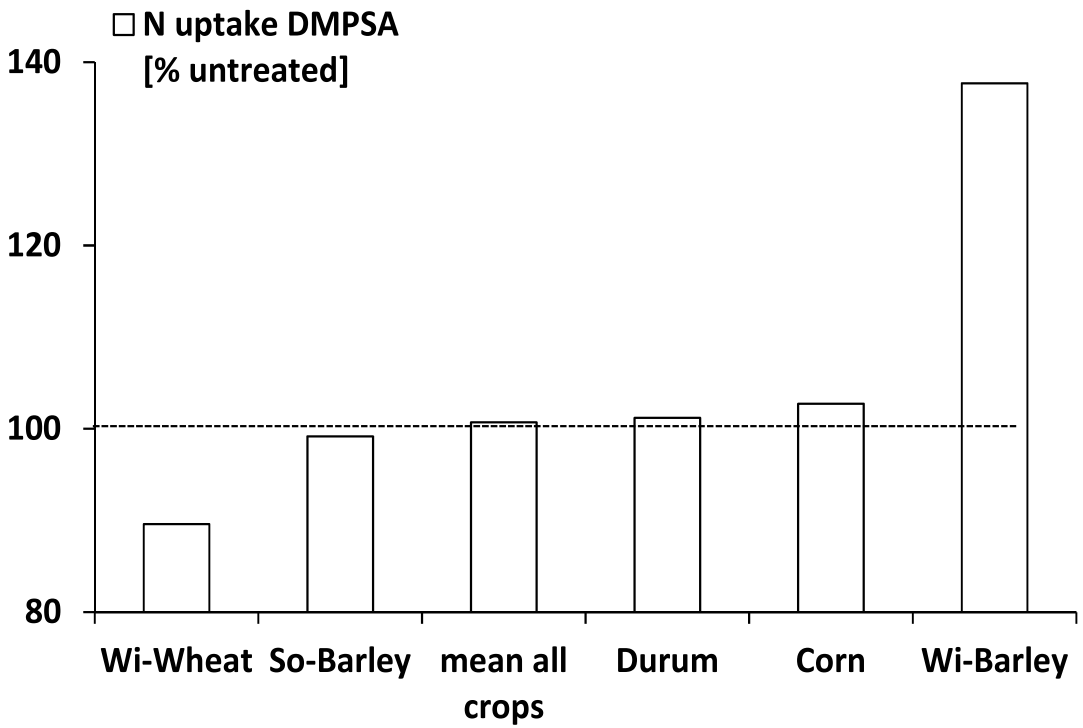
Summary + Outlook

Yield effects of different fertilizers inhibited with DMPSA



Average increase of yield level by 4%
- not significant across trials but in many individual trials

NUE effects of different fertilizers inhibited with DMPSA on cereals



Average increase of NUE by 2%

Summary + Outlook

Agroecological trials

- DMPSA decreased N_2O emissions compared to untreated CAN in both years
- Yield scaled N_2O emissions from CAN+DMPSA < unfertilized control
- Grain yield and total DM yield in most cases highest with DMPSA
- DMPSA also effective in reducing N_2O emissions from nitrate and soil N sources

Incubation

- DMPSA radically decreased N_2O emissions compared to untreated CAN
- Ammonium stabilized for about 4 weeks

Yield trials

- Positive yield effects in most trials and for all kind of crops (on average + 4%)
- NUE increased or unaffected (on average + 2%)

Outlook

- Identification of optimal application conditions and rates for DMPSA inhibited fertilizers
- Combination with other inhibitors to provide optimal agronomic and environmental effects