Inoculants of leguminous crops for mitigating soil emissions of the greenhouse gas nitrous oxide

Catherine Hénault, Cécile Revellin

Inoculants of leguminous crops for mitigating soil emissions of the greenhouse gas nitrous oxide

Catherine Hénault and Cécile Revellin

UMR Microbiologie des Sols et de l'Environnement – Dijon – France

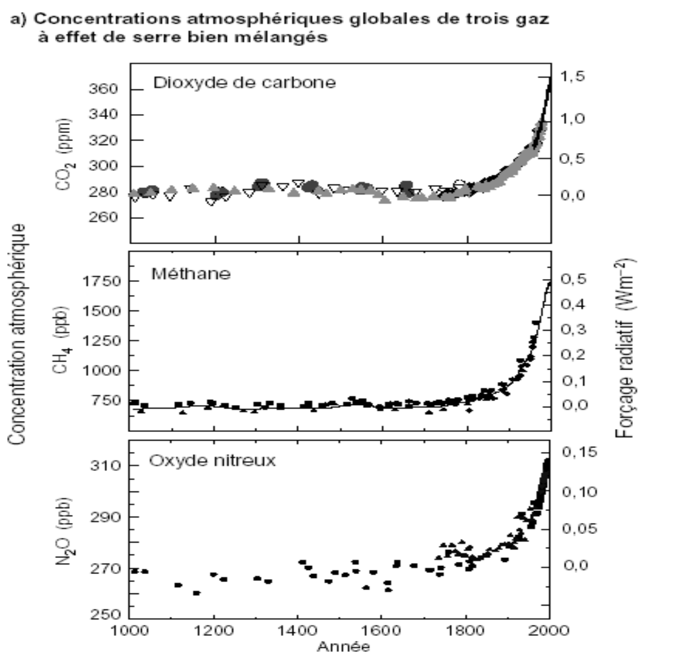
UR SOLS – Orléans – France

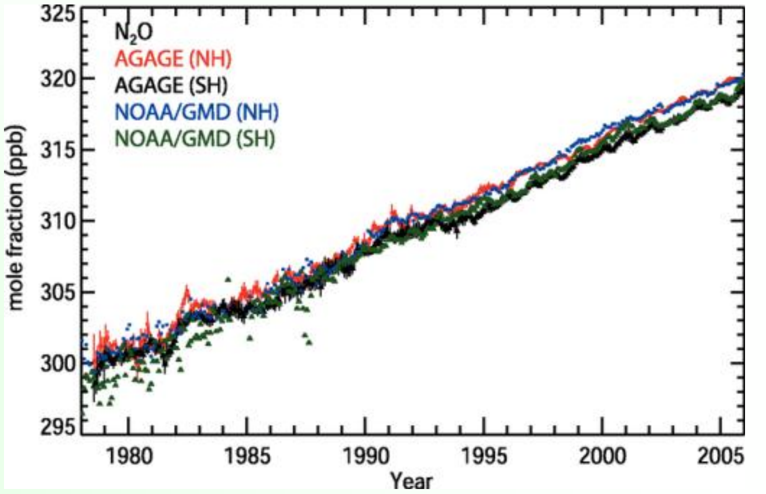
REGION DE BOURGOGNE

Agricultural Ecology Research: its role in delivering sustainable farm systems – Dundee, 15-16 june 2011

CHANGES IN ATMOSPHERIC CONCENTRATIONS OF TRACE GASES

Atmospheric concentrations of greenhouse gases



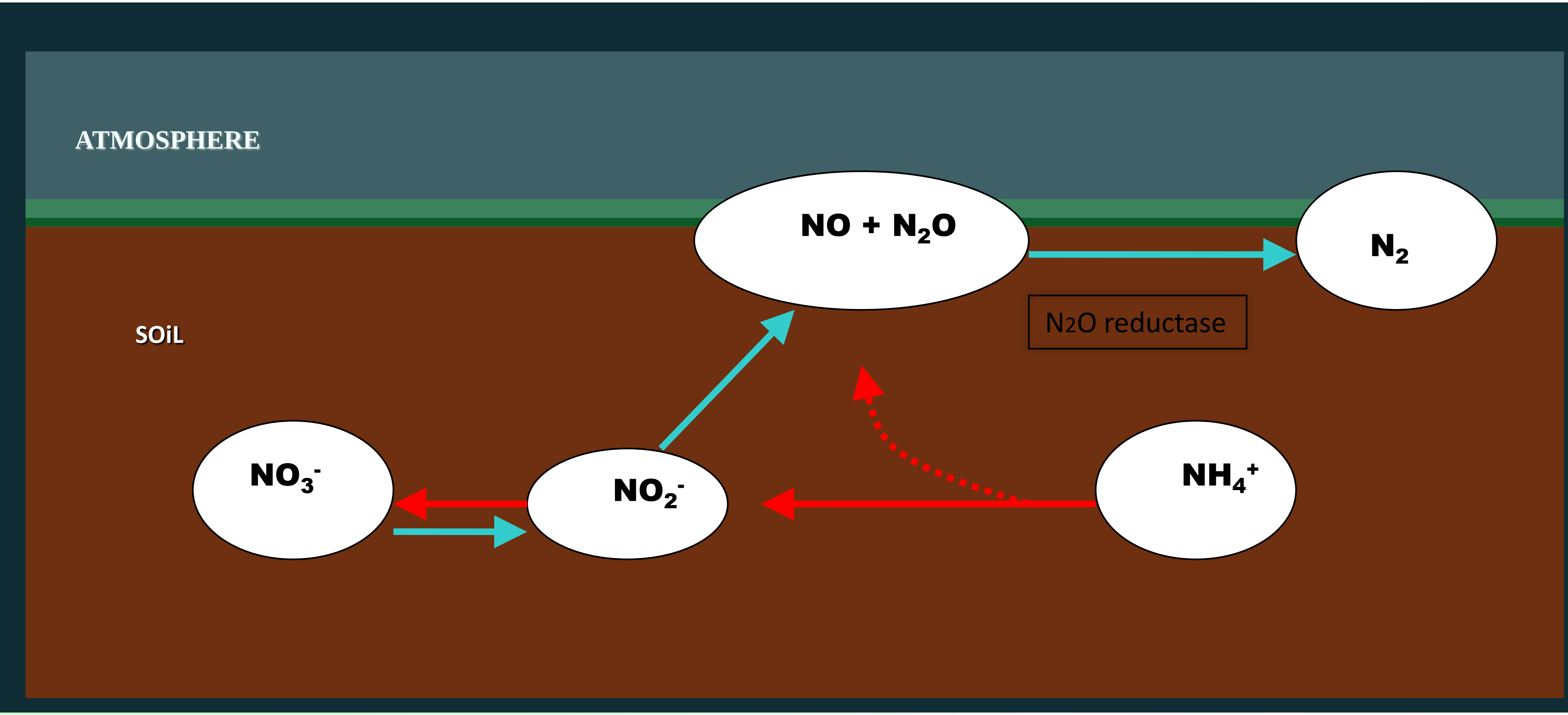


GAS	GWP (100 years)
CO_2	1
CH_4	23
N_2O	296

SOURCES OF N_2O (Tg N-N_2O y^{-1}), from IPCC 2007

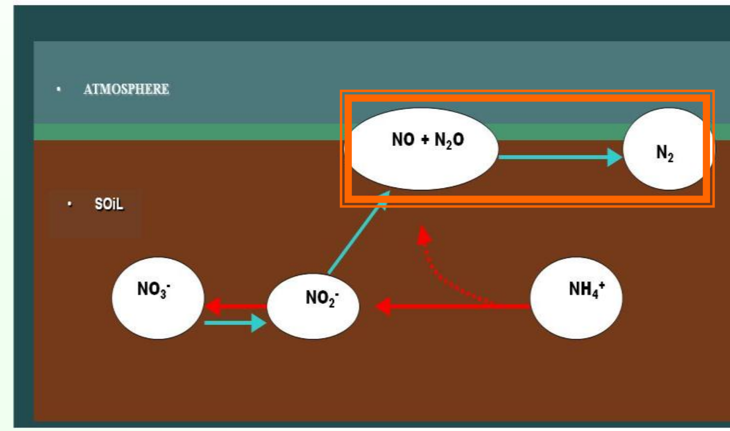
AR4 (2007)		
SOURCE	value	range
Anthropogenic sources		
Fossil fuel combustion and Industrial processes	0.7	0.2-1.8
Agriculture	2.8	1.7-4.8
Rivers, estuaries, coastal zones	1.7	0.5-2.9
Biomass and biofuel burning	0.7	0.2-1.0
Human excreta	0.2	0.1-0.3
Atmospheric deposition	0.6	0.3-0.9
Anthropogenic total	**6.7**	
Natural sources		
Soils under natural vegetation	6.6	3.3-9.0
Oceans	3.8	1.8-5.8
Atmospheric chemistry	0.6	0.3-1.2
Natural sources total	**11**	
Total sources	**17.7**	**8.5-27.7**
Atmospheric sink	**12.3**	
Atmopheric increase	**3.9**	
Unbalanced	**1.5 ???**	**large range**

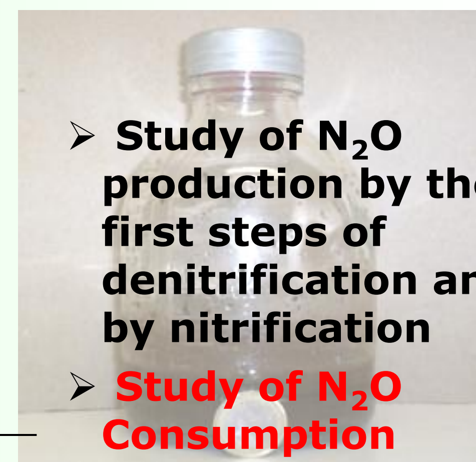
MECHANISMS INVOLVED IN N_2O BUDGET IN SOILS



denitrification (anaerobic) – nitrification (aerobic)

REGULATION OF THE LEVEL OF N_2O EMISSION BY THE REDUCTION OF N_2O



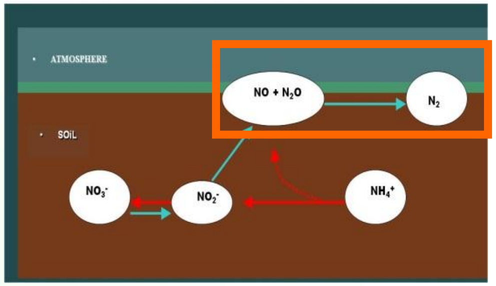


- **Study of N_2O production by the first steps of denitrification and by nitrification**
- **Study of N_2O Consumption**

(From Hénault et al., 2001)

OBJECTIVES OF THE STUDY

- To mitigate N_2O emission by managing the N_2O to N_2 reduction, specially in soils where this function is inefficient
- By managing soil microbial communities : use of microorganisms that grow in symbiosis with crop plants
- Some *rhizobia*, symbionts of leguminous crops possess the *nosZ* genes coding for the enzyme involved in the N_2O reduction (Sameshima-Saito et al., 2006)



⇨ **To crop some leguminous**

- Inoculated with strains carrying the *nosZ genes*
- On soil emitting high levels of N_2O due to an inefficient N_2O reduction

$[\text{SOIL}]_{PhN_2ORed-} + [\text{Plant + Inoculant}]_{PhN_2Ored+} \Rightarrow [\text{SOIL + Plant + Inoculant}]_{PhN_2ORed+}$

STEPS OF THE STUDY

- **A greenhouse experiment** for testing the previous equation

$$[\text{SOIL}]_{\text{PhN}_2\text{ORed-}} + [\text{Plant + Inoculant}]_{\text{PhN}_2\text{Ored+}} \Rightarrow [\text{SOIL + Plant + Inoculant}]_{\text{PhN}_2\text{ORed+}}$$

- Some **laboratory experiments** to develop knowledges on the process

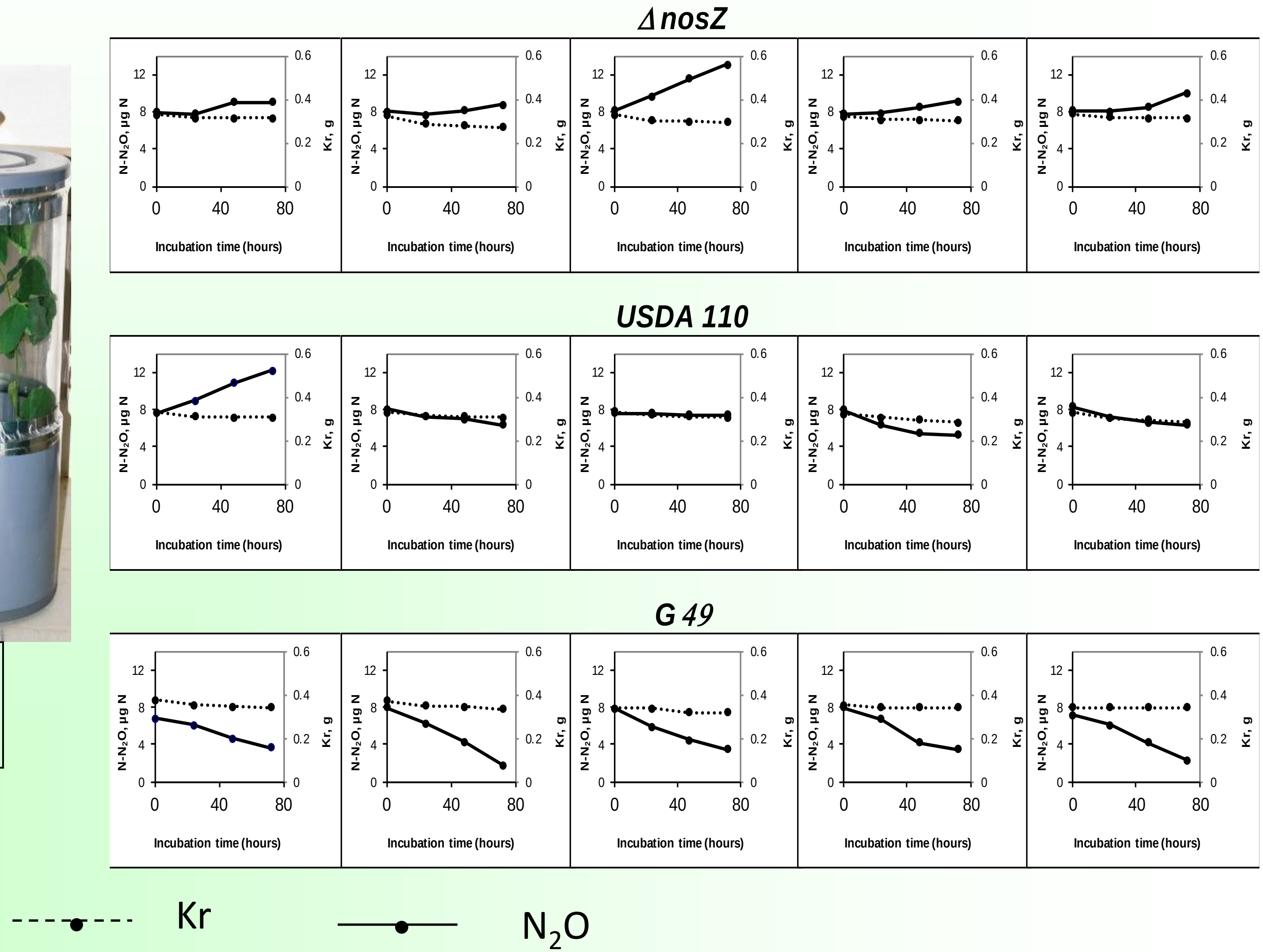
- A **modelling approach** to assess quantitative benefits of this process at the field scale

MAIN USED MATERIALS

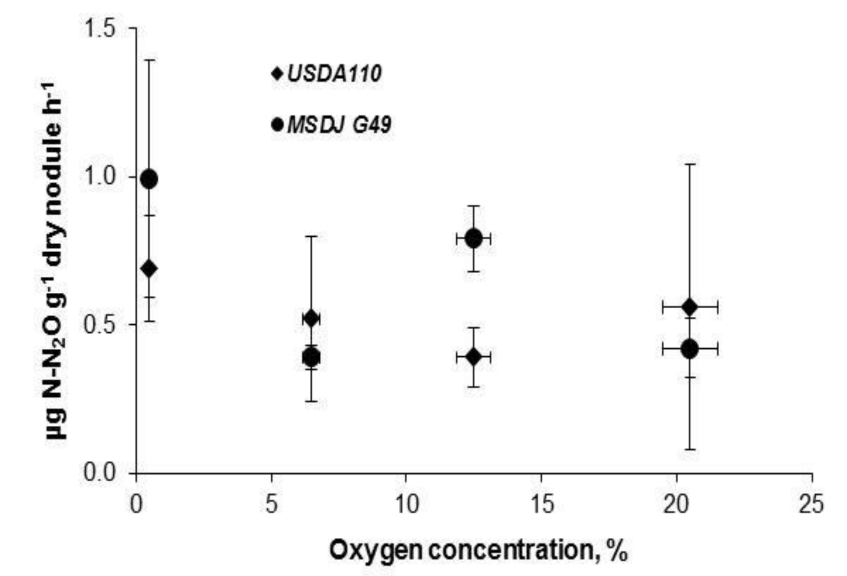
- Soybean plants inoculated with different strains *of Bradyrhizobium japonicum*
- Gas chromatography

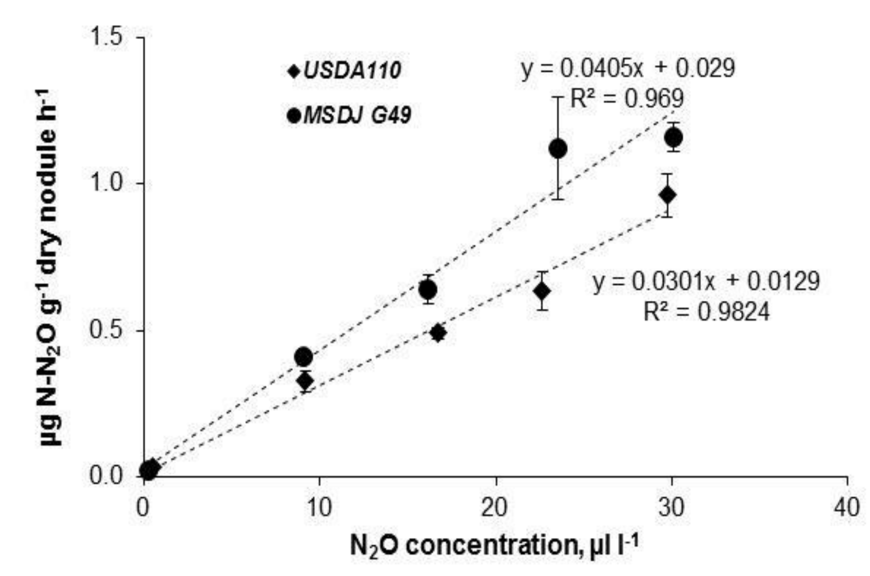
GREENHOUSE EXPERIMENT

Soil inefficient to reduce N_2O



LABORATORY EXPERIMENT





QUANTIFICATION BY A MODELING APPROACH

THE MODEL

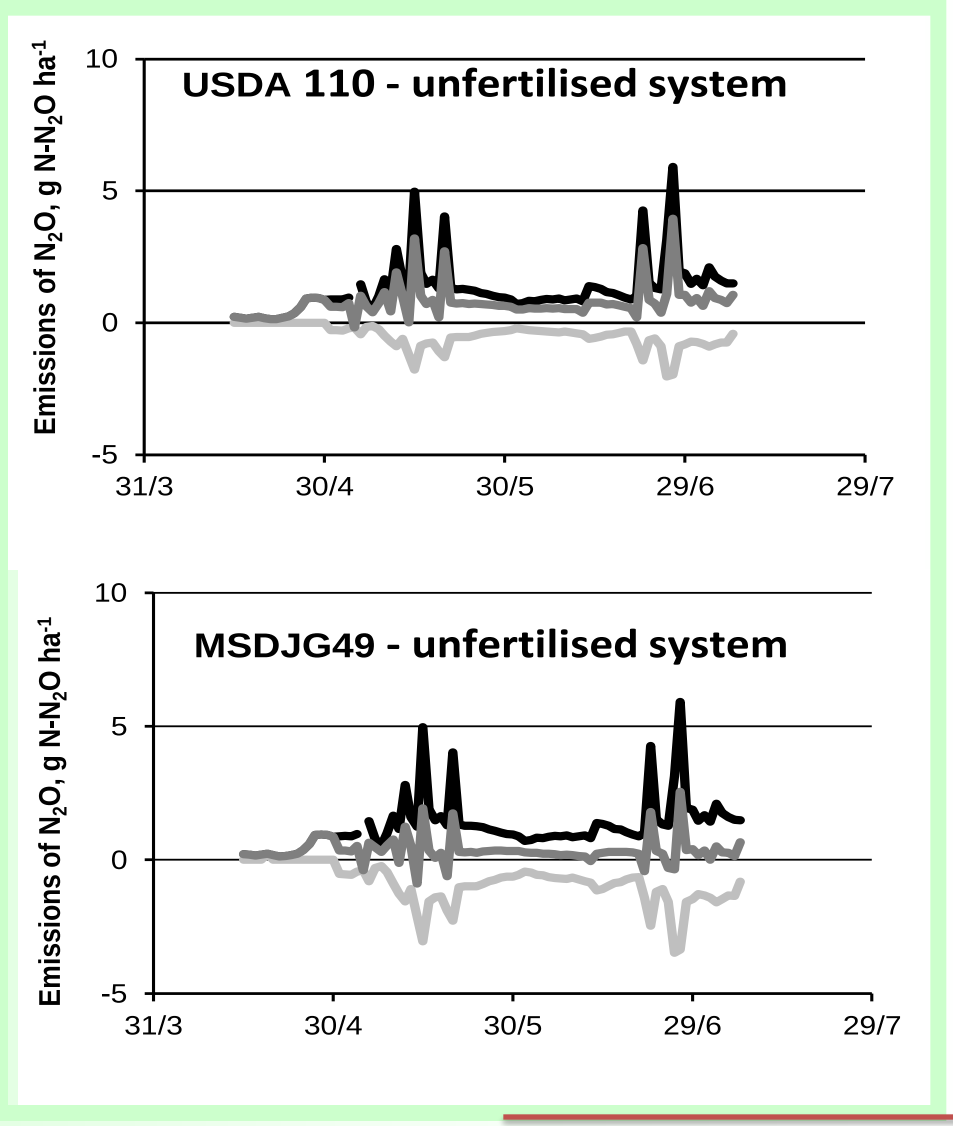
A new version of the NOE model (Hénault et al., 2005) that includes the reduction of N_2O by rhizobia

Parametrisation of the model using results obtained during both the laboratory and greenhouse experiments

N_2O emission by soil

by nodules inoculated into soybean

in a hypothetical system including active nodules



CONCLUSIONS

- Switch from an N_2O emitting system to a consuming one by means of the inoculation of strains containg the *nosZ* gene

- Observations
  - that the process is insensitive to the O_2 concentration
  - that rates increase with the ambient N_2O concentration
  - that the efficiency of the process is strain dependant

- Assessment of a significant benefit of the process at the field scale

$\Rightarrow$ To **measure** the environmental benefit of the process on the field scale

Thank you