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

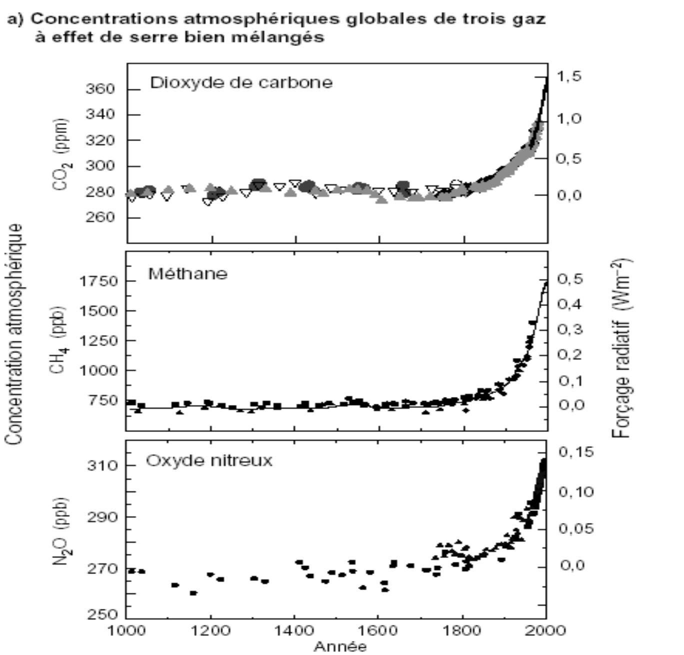
Catherine Hénault and Cécile Revellin

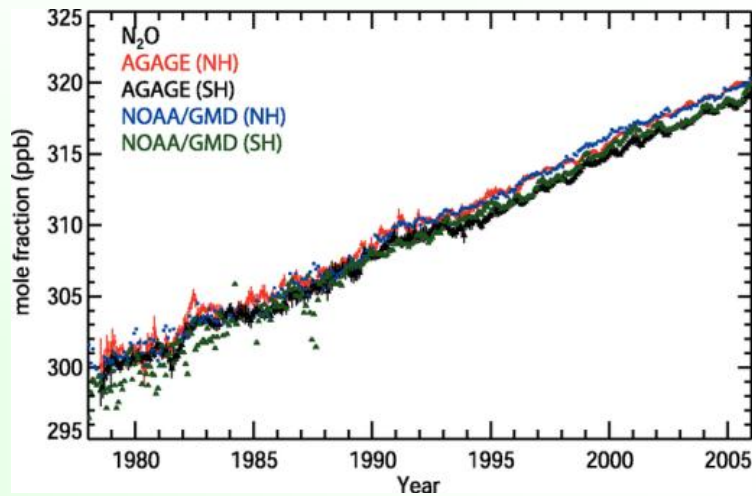
UMR Microbiologie des Sols et de l'Environnement – Dijon – France

UR SOLS – Orléans – France

CHANGES IN ATMOSPHERIC CONCENTRATIONS OF TRACE GASES

Atmospheric concentrations of greenhouse gases



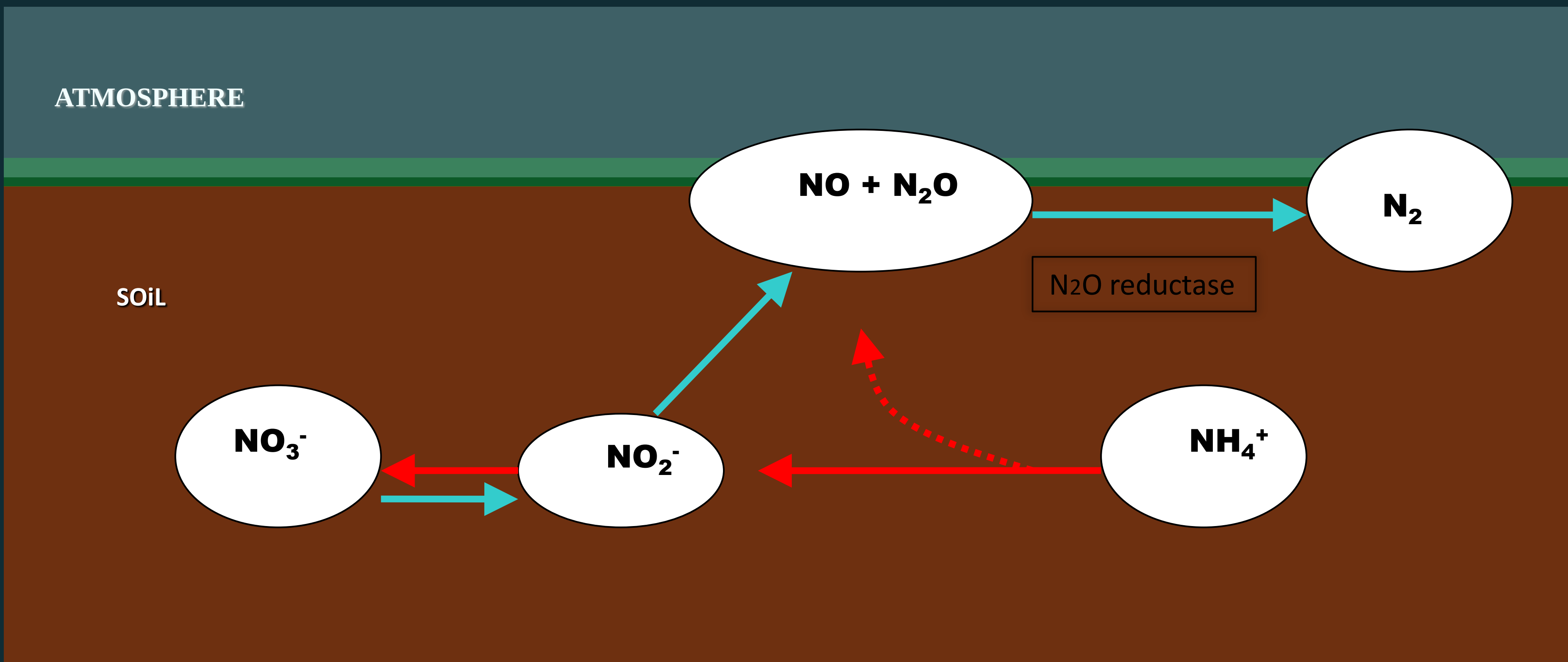


GAS	GWP (100 years)
CO_2	1
CH_4	23
N_2O	296

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

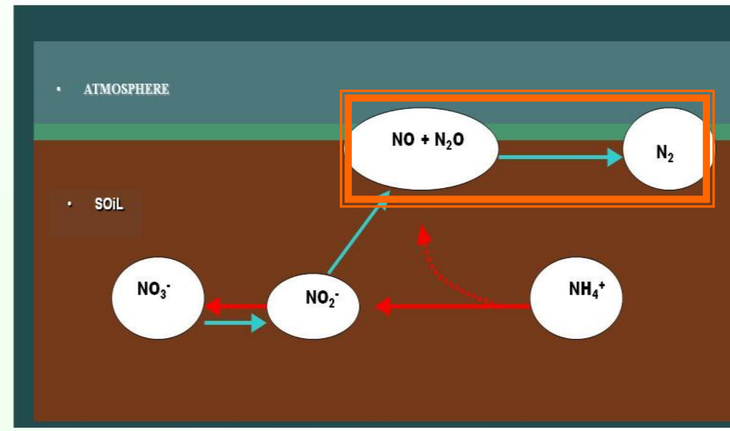
AR4 (2007)		
SOURCE	value	range
Anthropogenic sources		
Fossil fuel combustion and Industrial processes	0.7	0.2-1.8
Agriculture	2.8	1.7-4.8
Rivers, estuaries, coastal zones	1.7	0.5-2.9
Biomass and biofuel burning	0.7	0.2-1.0
Human excreta	0.2	0.1-0.3
Atmospheric deposition	0.6	0.3-0.9
Anthropogenic total	**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**

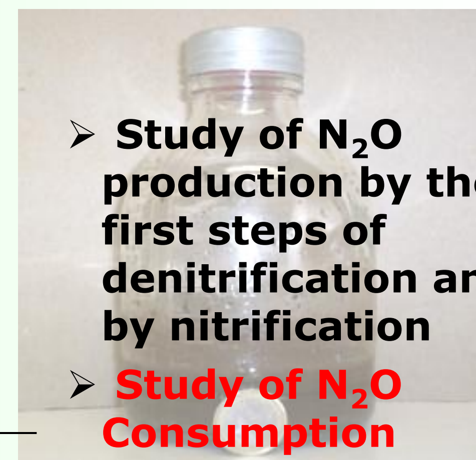
MECHANISMS INVOLVED IN N_2O BUDGET IN SOILS



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**

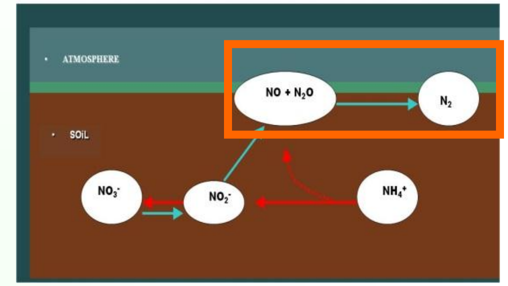
(From Hénault et al., 2001)

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

$[SOIL]_{PhN_2ORed-}$ + [Plant + Inoculant $]_{PhN_2Ored+}$ ⇨ [SOIL + Plant + Inoculant $]_{PhN_2ORed+}$

STEPS OF THE STUDY

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

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

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

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

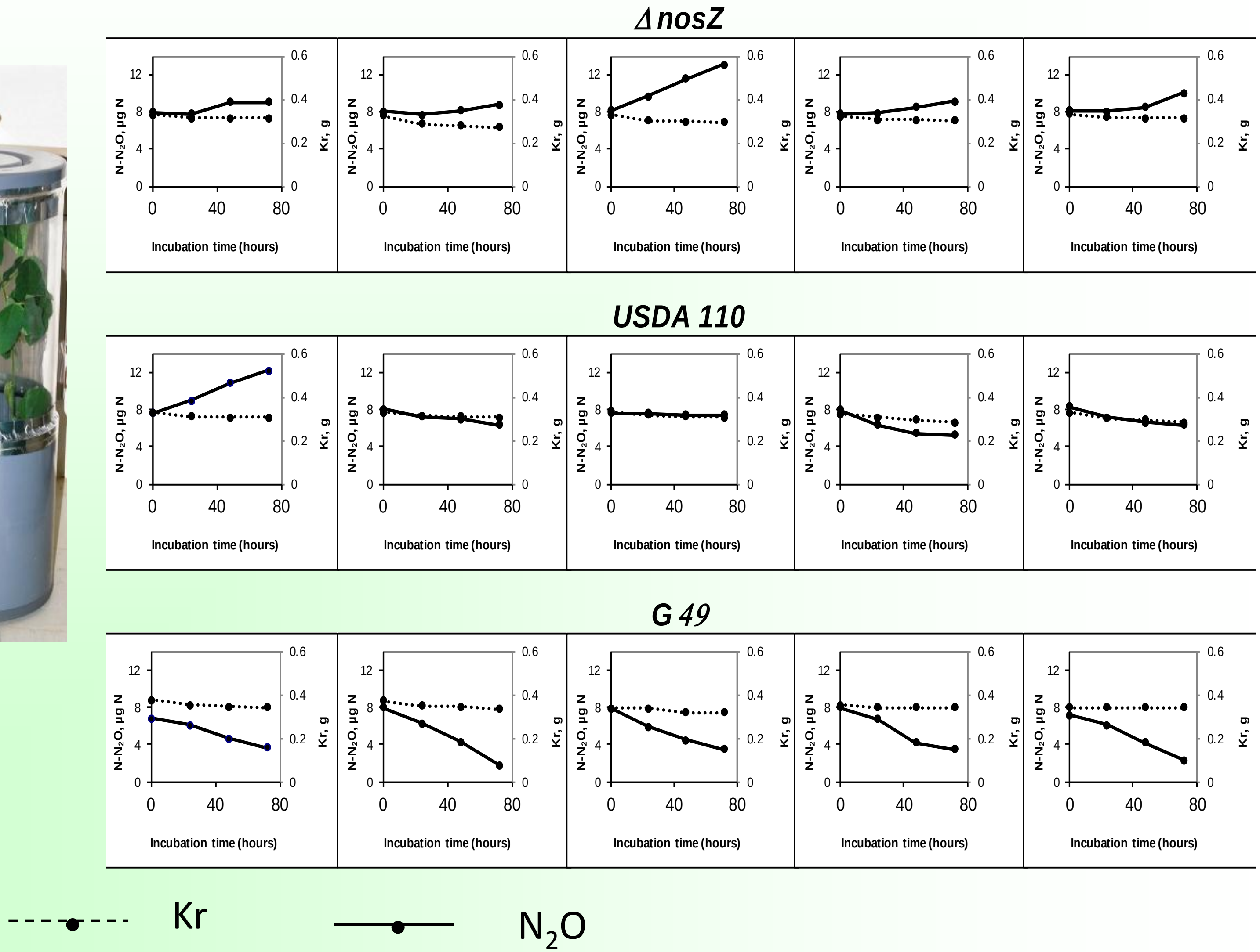
MAIN USED MATERIALS

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

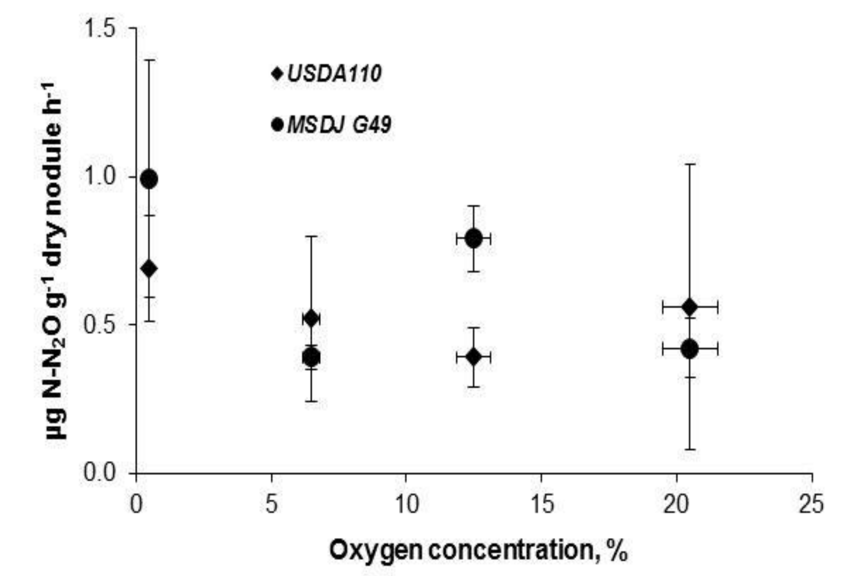
INRA

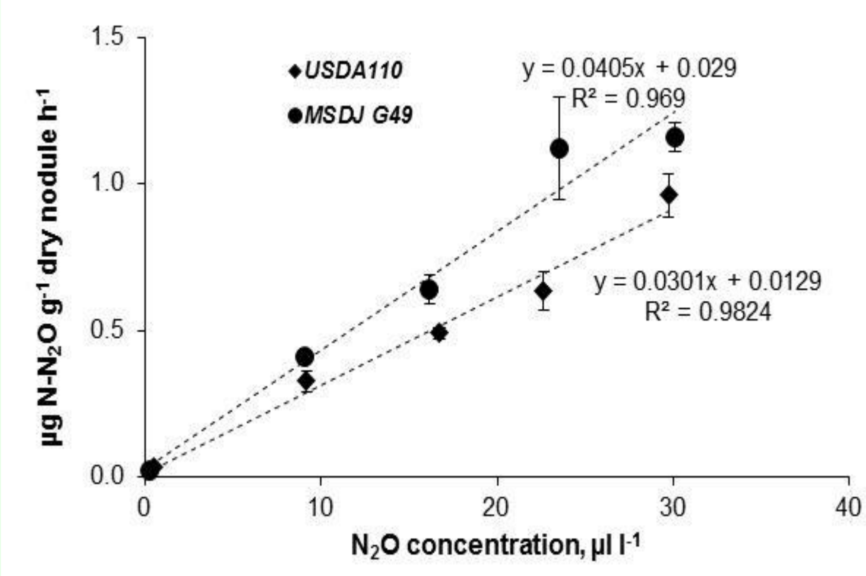
GREENHOUSE EXPERIMENT

Soil inefficient to reduce N_2O



LABORATORY EXPERIMENT



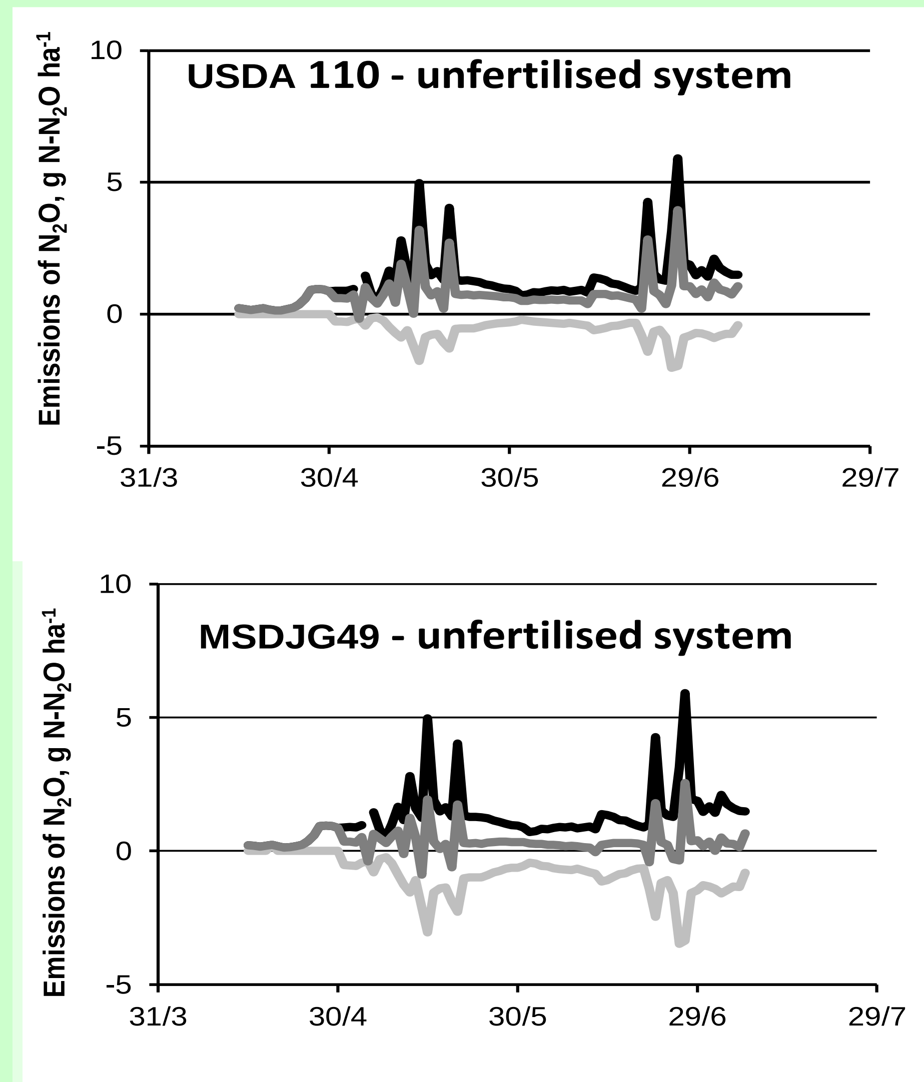


QUANTIFICATION BY A MODELING APPROACH

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

⇒ To **measure** the environmental benefit of the process on the field scale

Thank you