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## Impacts of Integrated Weed management in cropping systems on N<sub>2</sub>O emissions from soils

Anthony Vermue, Catherine Hénault, Arnaud Coffin, Nicolas Munier-Jolain,  
Bernard Nicolardot

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# Session 4 - Other management practices and combination of techniques

Chair: Alberto Sanz-Cobeña

Co-chair: Bob Rees

**Key note lecture - Per Ambus**

**Short oral presentations:**

- Abdalla Mohamed
- Joël Leonard
- Anthony Vermue, Catherine Hénault
- Yam Kanta Gaihre



# Key note lecture

Other management practices and N<sub>2</sub>O emissions -  
Application of biochar as a tool to mitigate nitrous  
oxide emissions

Per Ambus

Center for Ecosystems and Environmental Sustainability

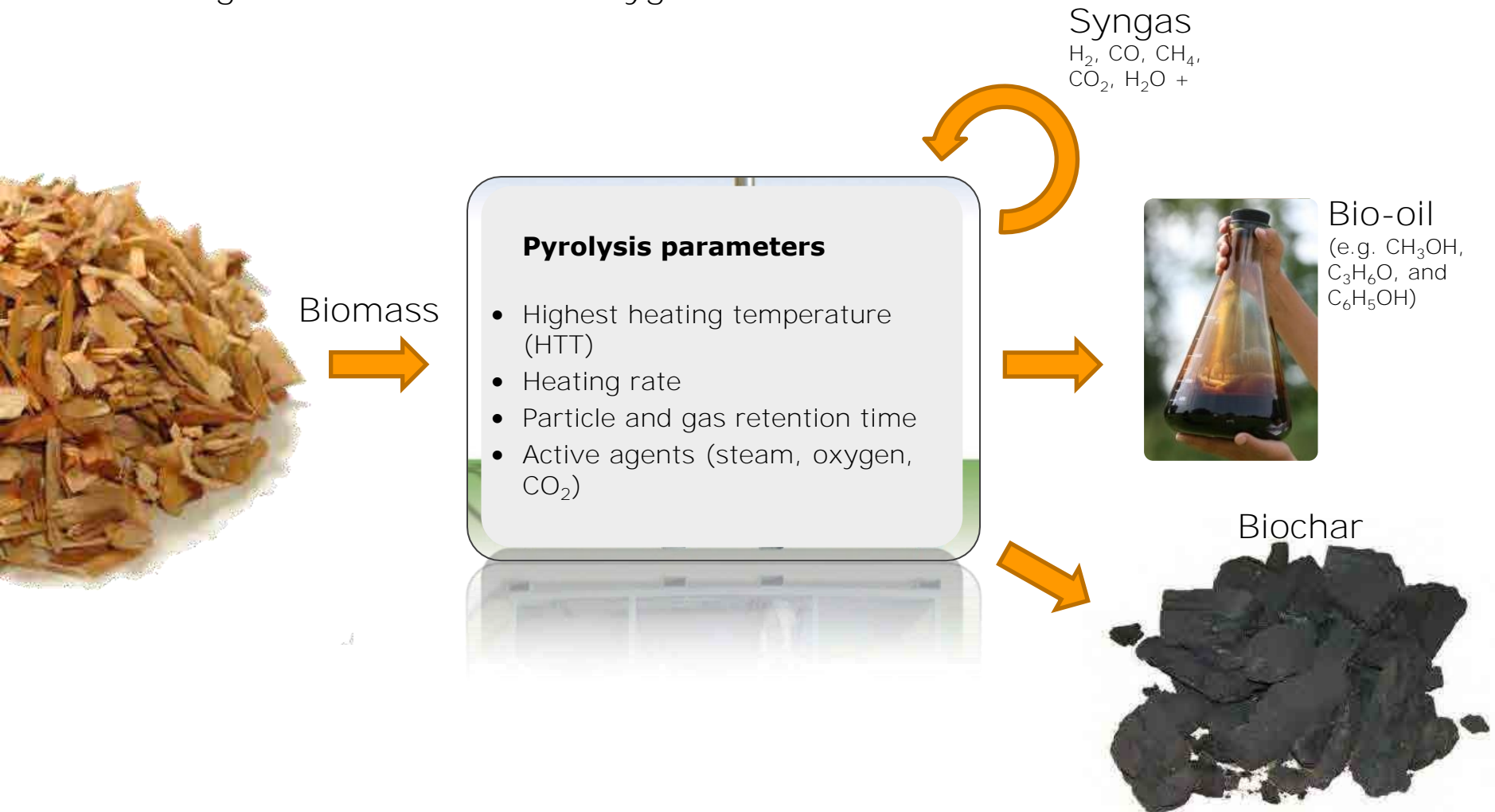
Chemical and Biochemical Engineering Department

Technical University of Denmark



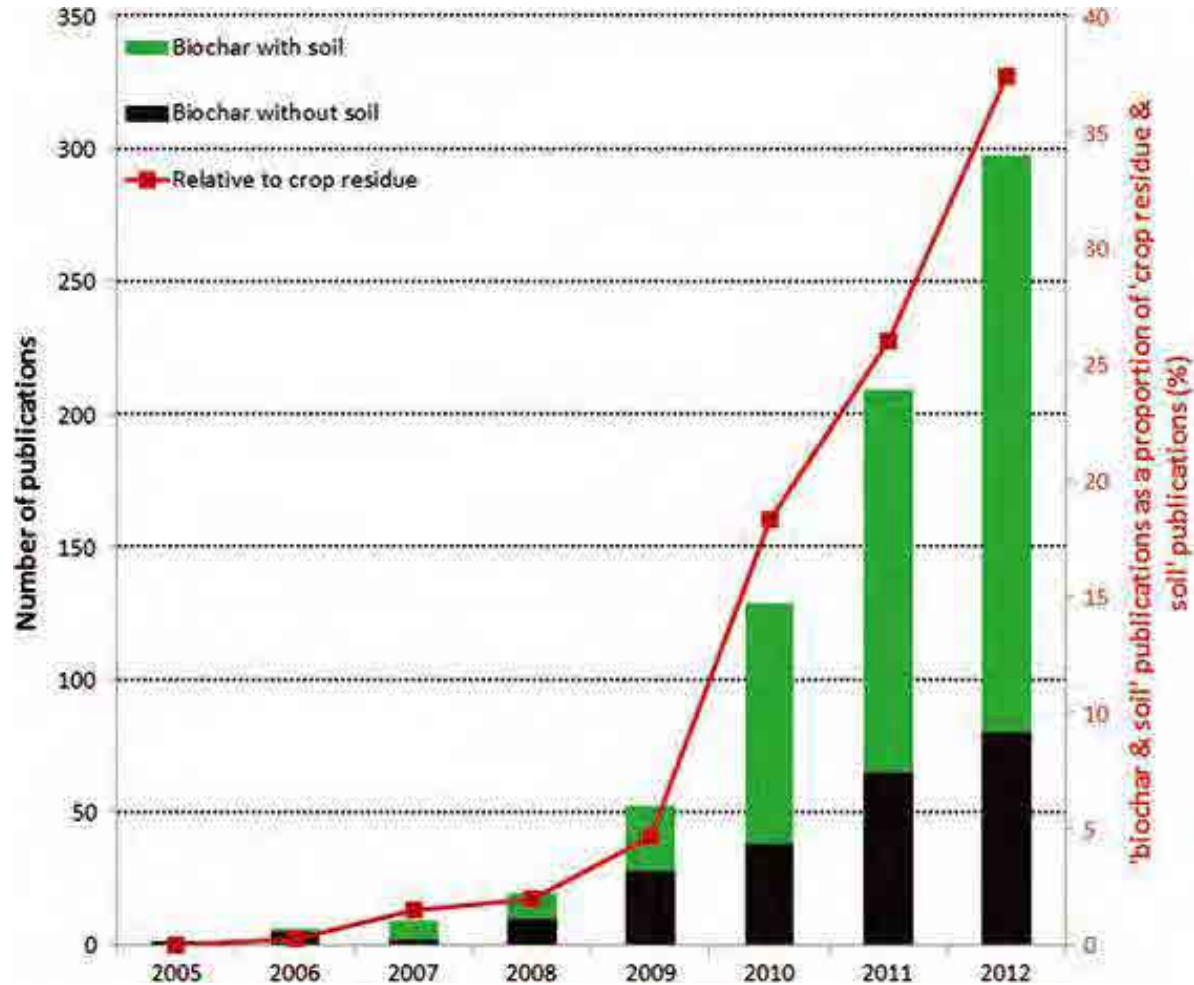
# Pyrolysis process

Heating of biomass without oxygen.





- Biochar sequesters **carbon**
- Biochar interacts with soil **nitrogen** availability
- Returns **nutrients** to the field (ash part)
- Biochar **increases pH** in acidic soils due to BC's content of bases (Ca, Mg, K etc.). Short term liming effect.
- Forms **aggregates** with the soil particles and stabilizes the soil
- Increases the cation exchange capacity (**CEC**) of the soil
- Increase **soil microbial biomass**
- Increases **water** holding capacity
- Increases soil porosity and **aeration**



*Verheijen et al. 2014*



## Slow pyrolysis



## Fast pyrolysis



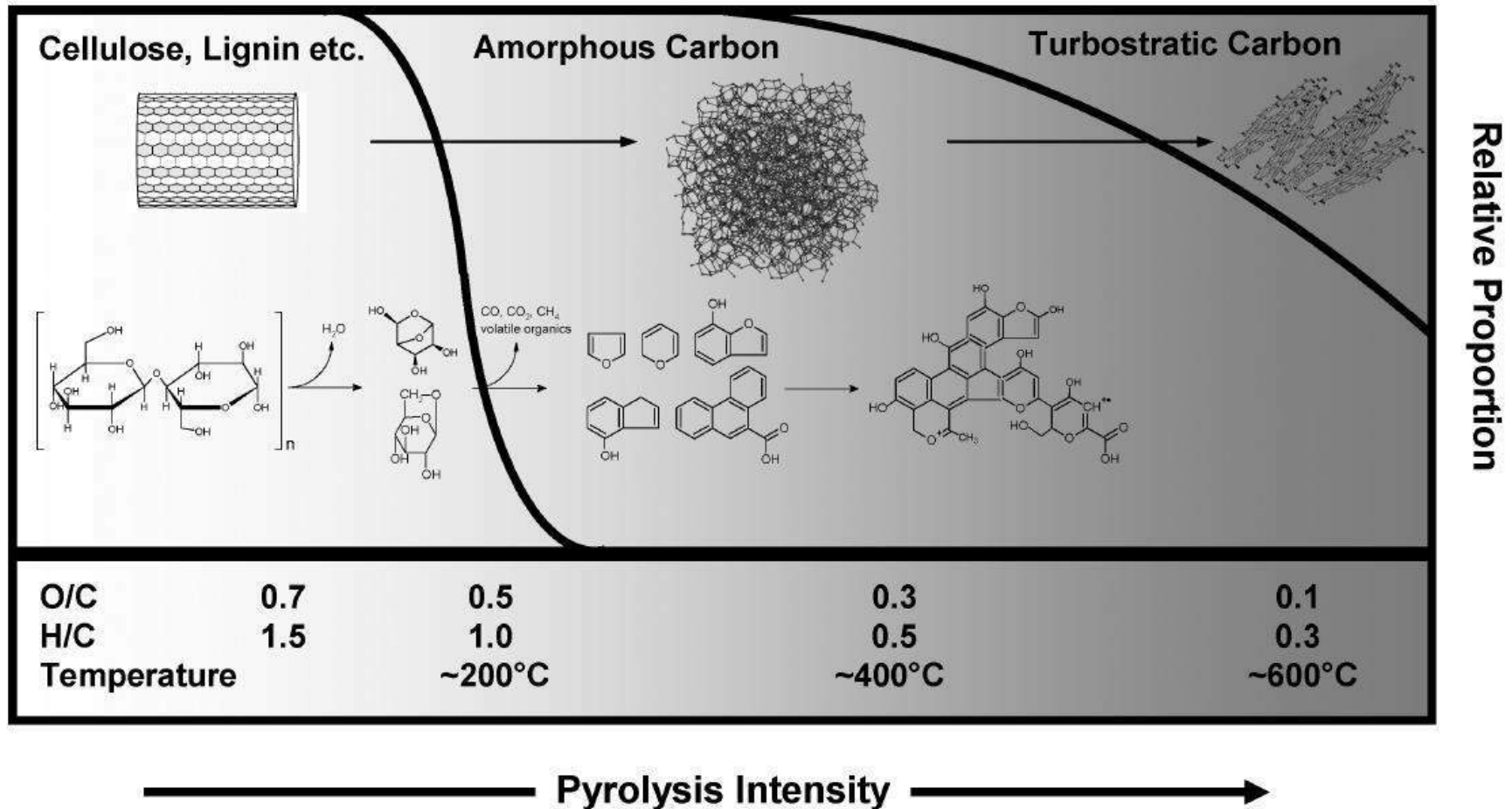
## Gasification



Dynamotive



# Feedstock transformation

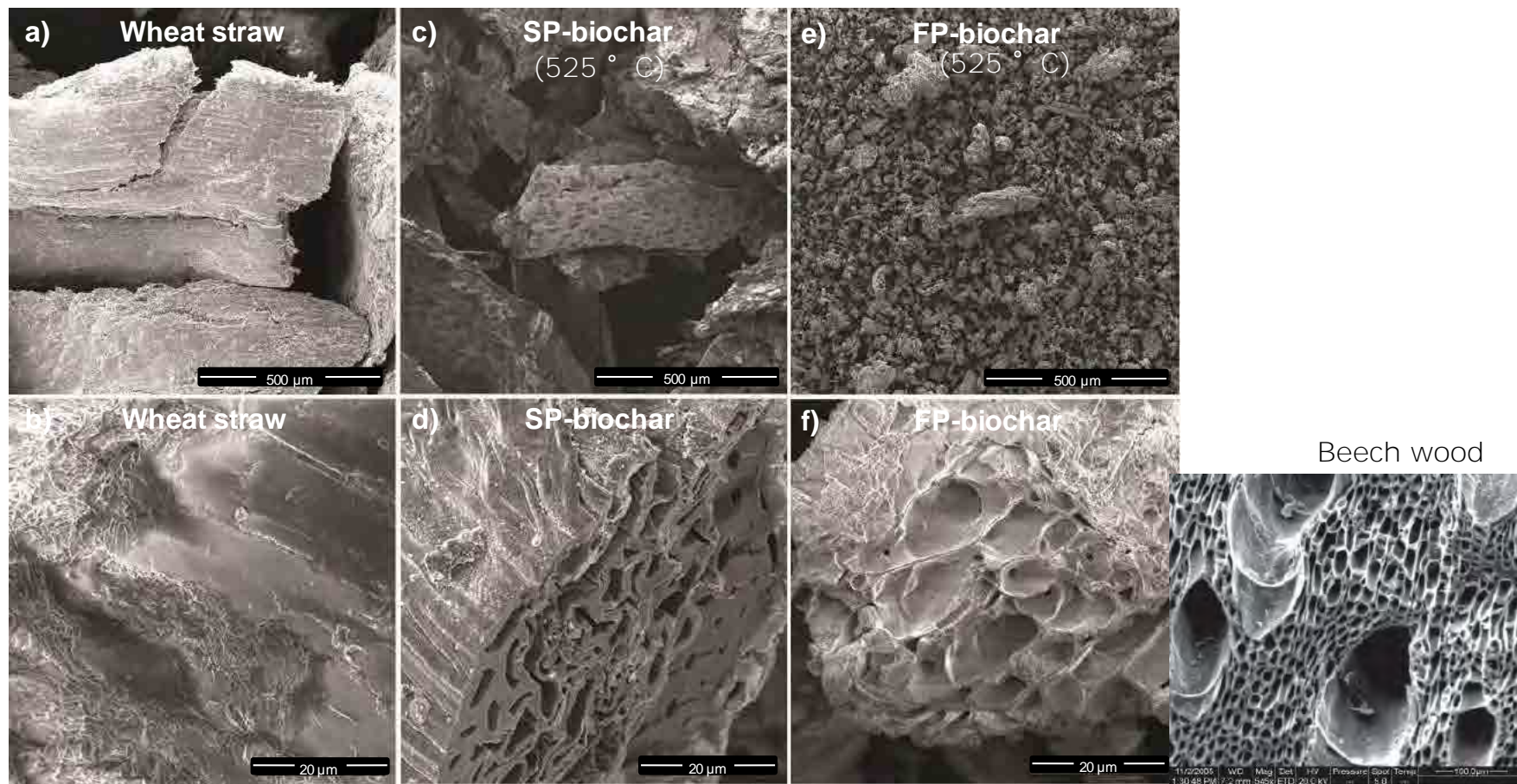


*Lehmann et al 2009.*





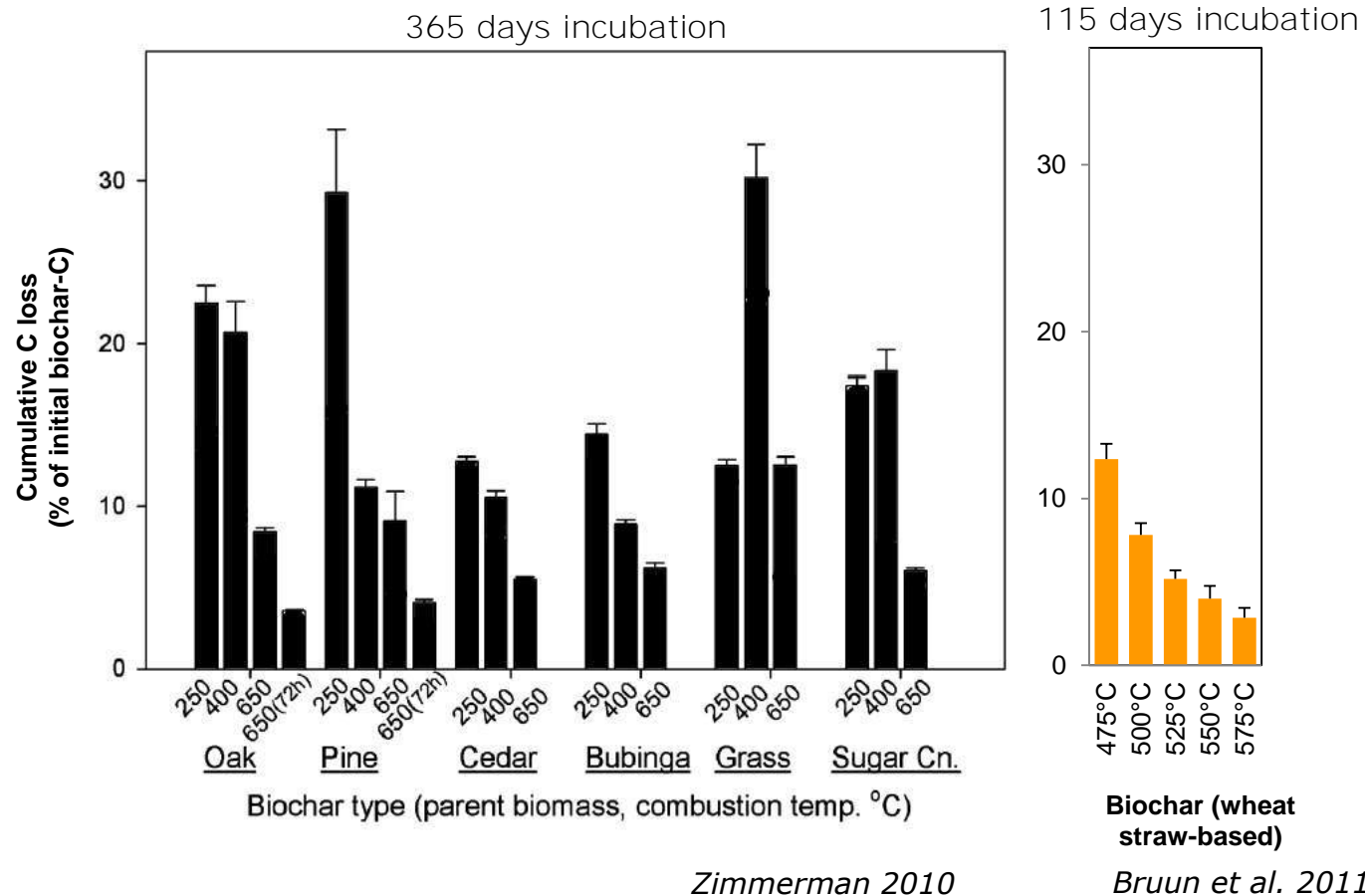
# Biochar microstructure



*Bruun et al. 2012.*

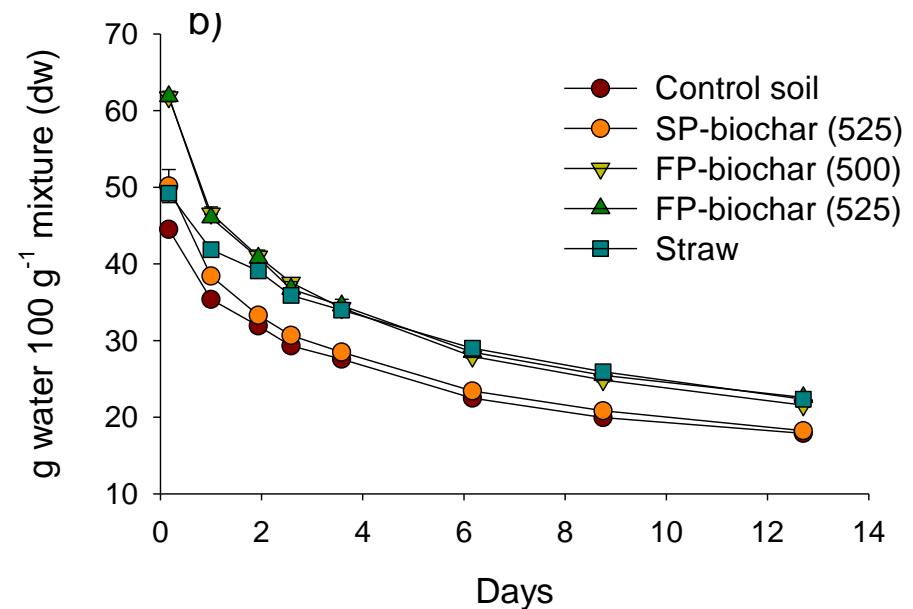
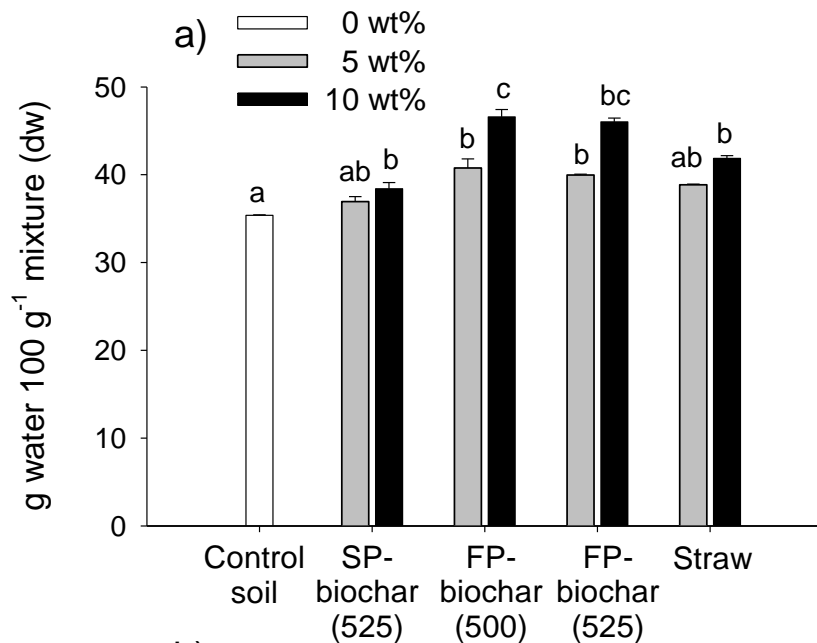


# Biochars stability depends on pyrolysis temperature and feedstock



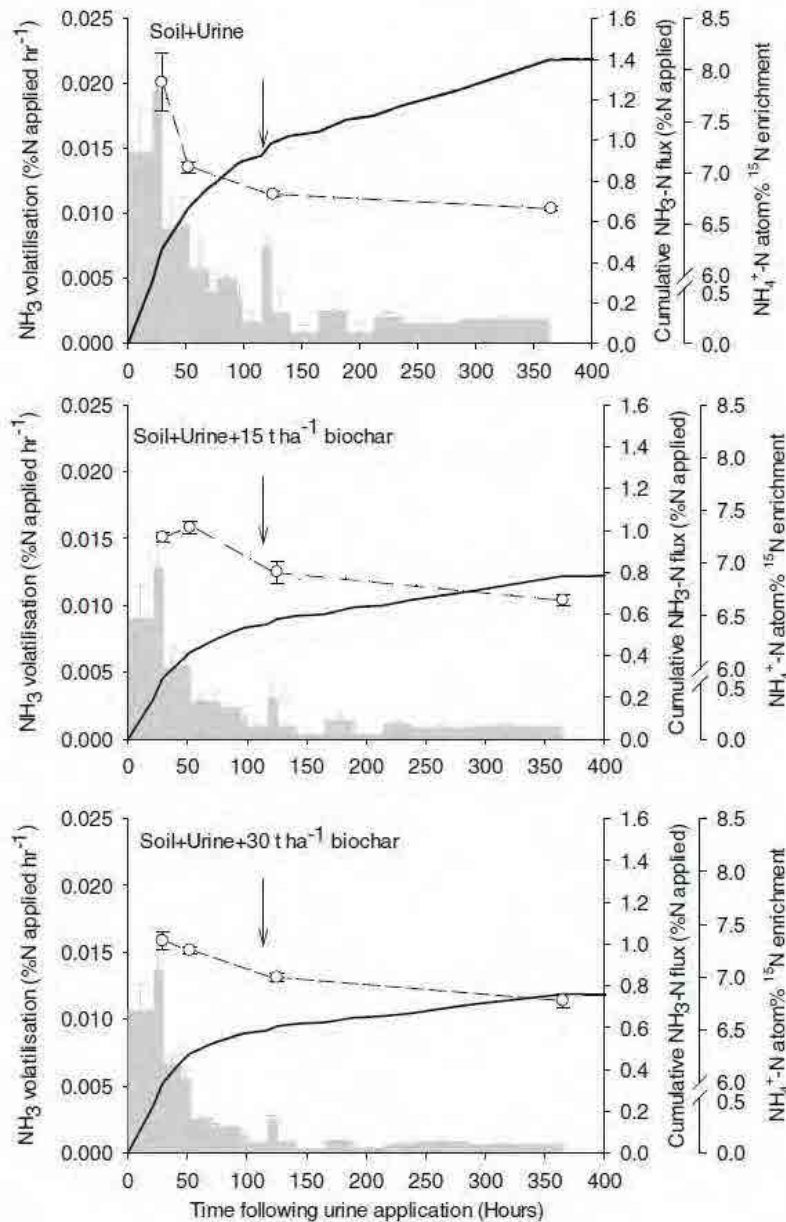


# Biochar increases soil water holding capacity



Application of biochar (10 wt%) to a sandy loam soil improved the WHC of the soil by 32 %





**BC captures NH<sub>3</sub>**

**Reduced NH<sub>3</sub> emission  
from urine spots**

**Adsorbed NH<sub>3</sub> is  
bioavailable**

*Taghizadeh-Toosi et al. 2012*

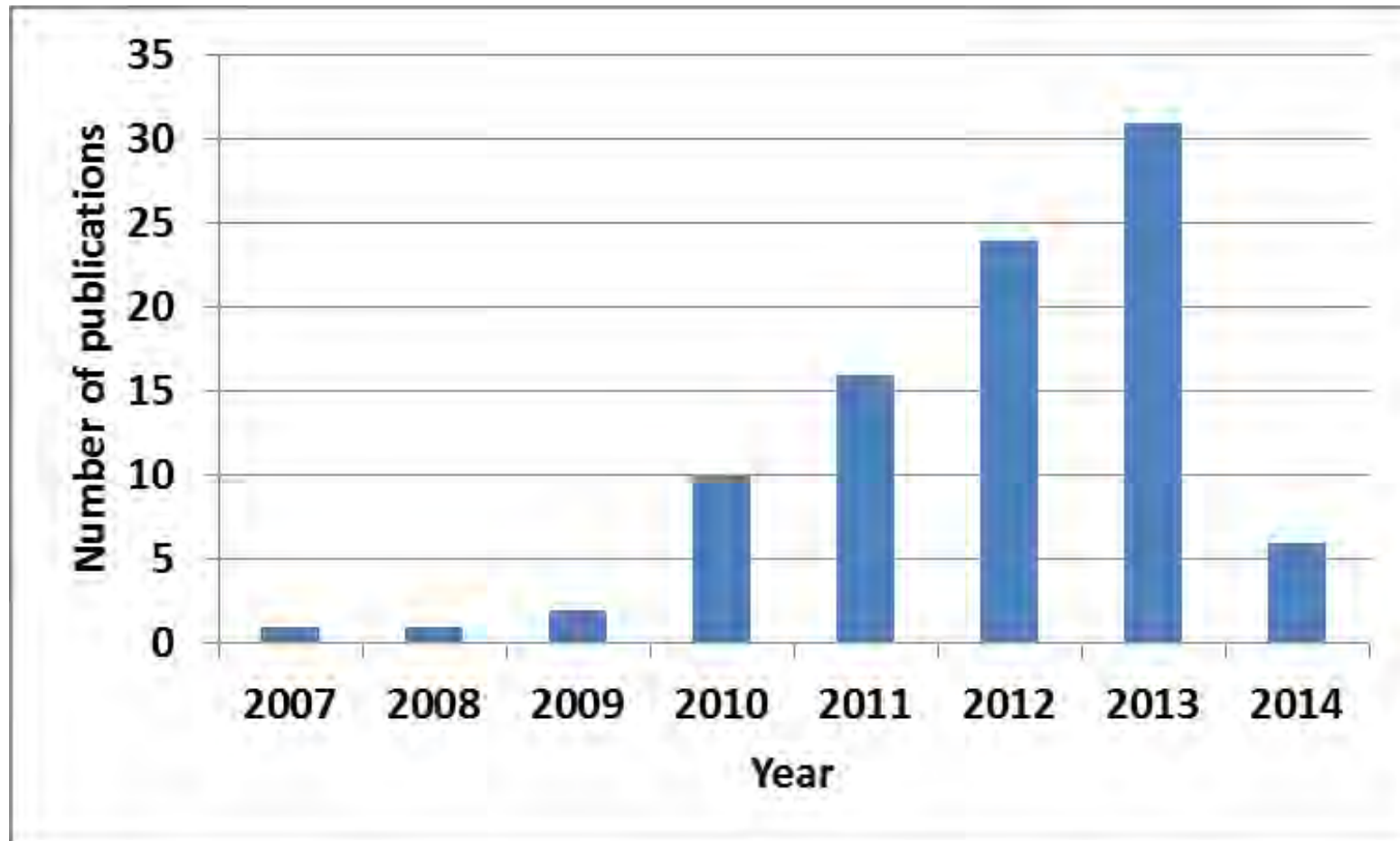


# Biochar and N<sub>2</sub>O emissions ?



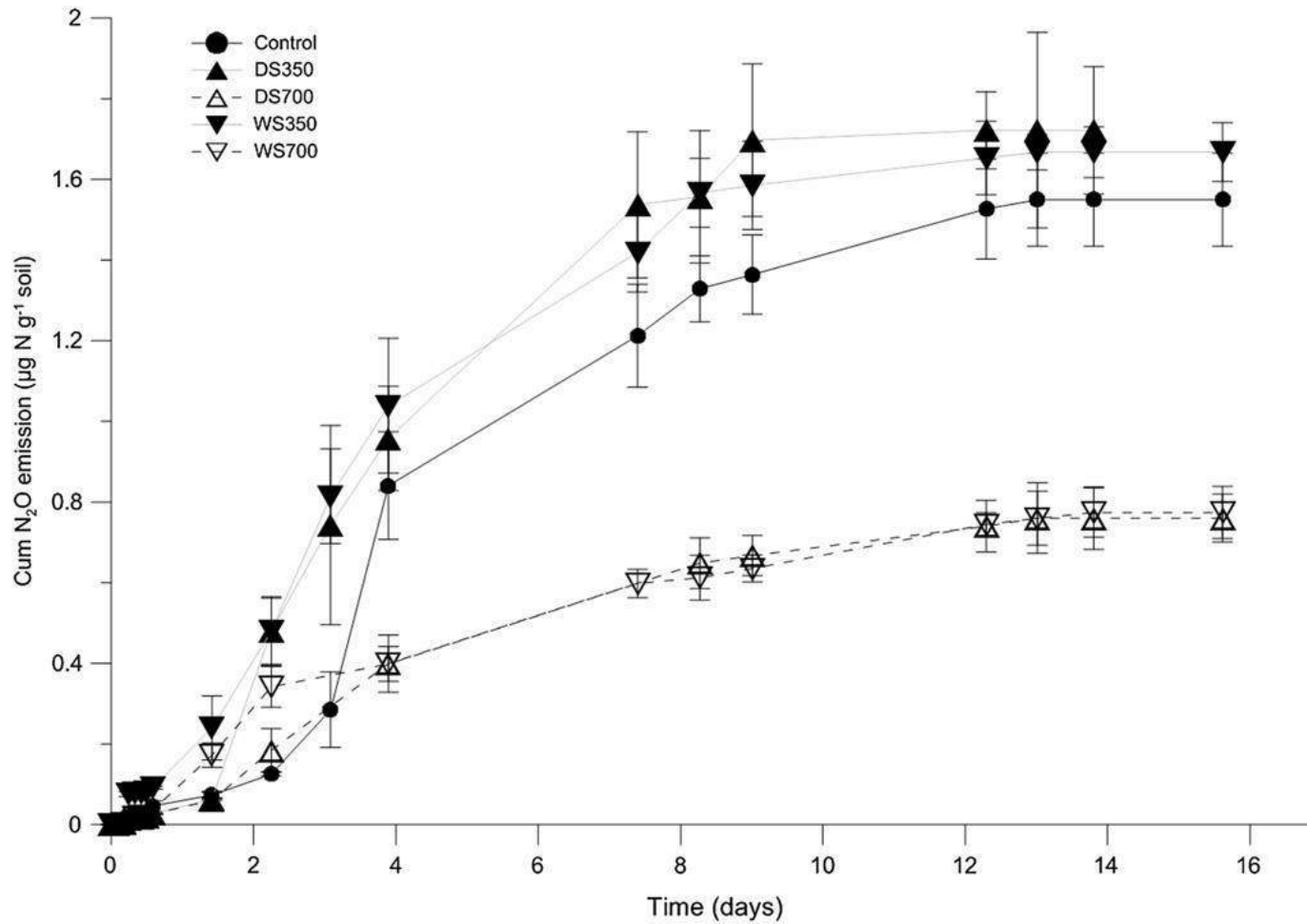


# 91 WoS publications since 2007 [char\* × nitrous oxide]





# N<sub>2</sub>O with different qualities of biochar

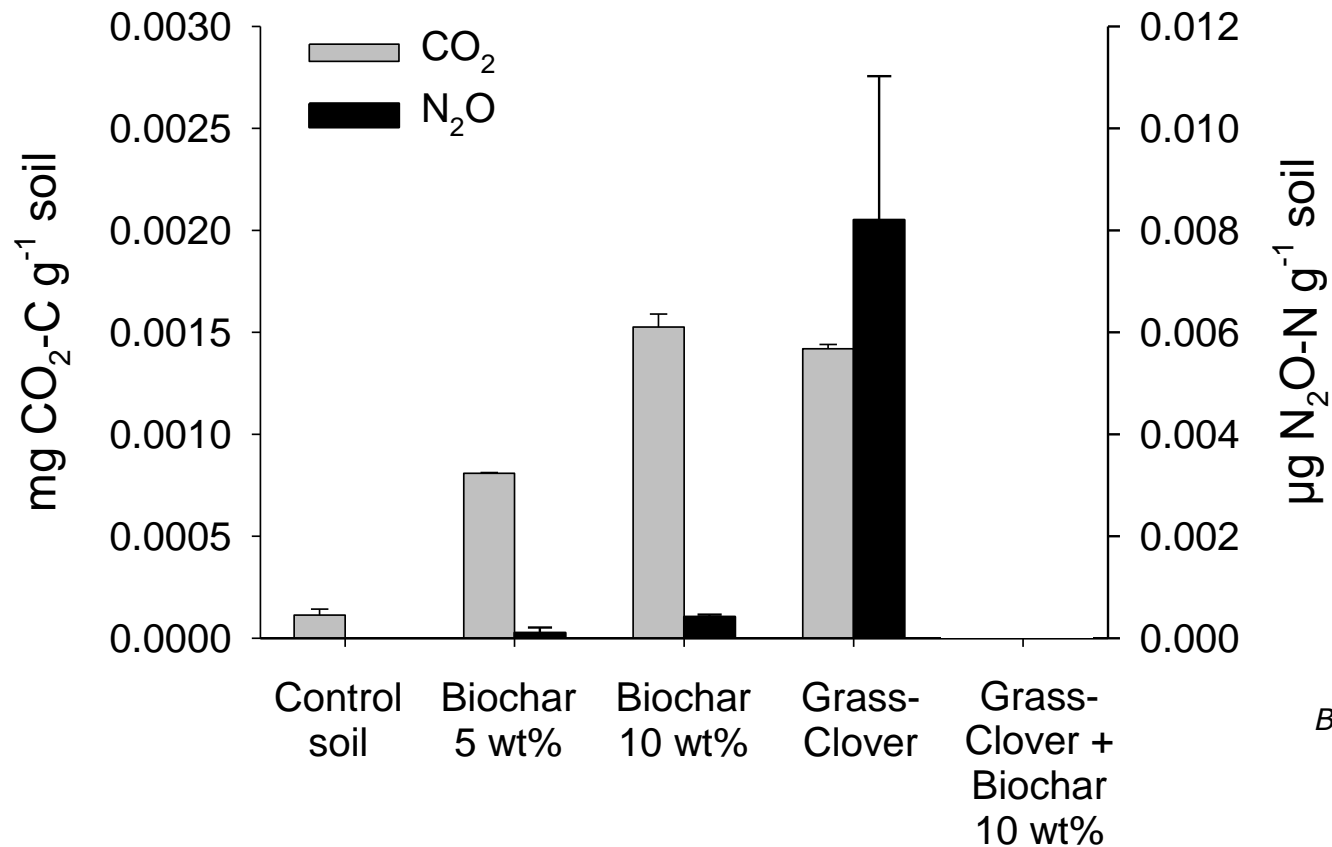


**N<sub>2</sub>O emission  
related to VOC  
content**

*Ameloot et al., 2013*



# FP-biochar effect on N<sub>2</sub>O soil emissions



*Bruun et al. 2011*

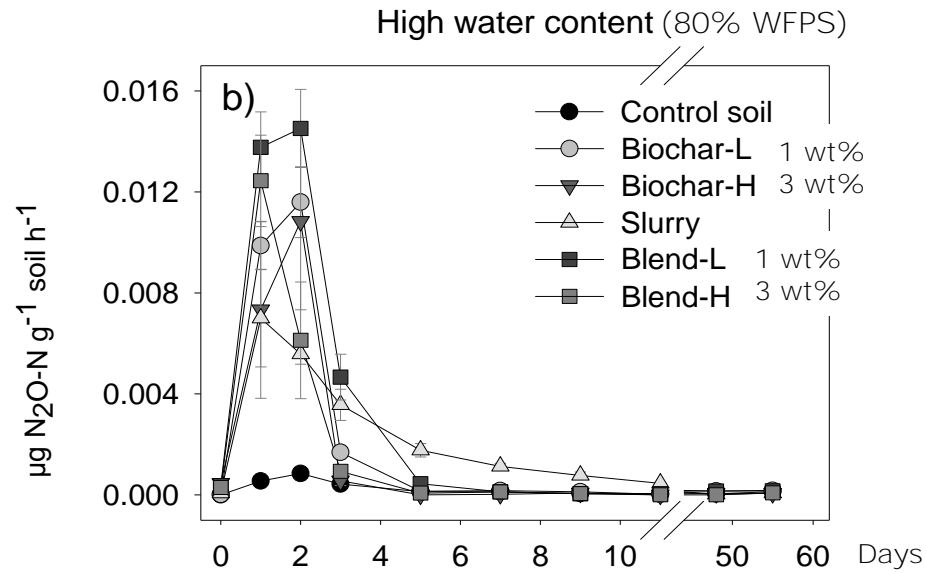




# Combine biochar with fertilizers to reduce N<sub>2</sub>O emission?

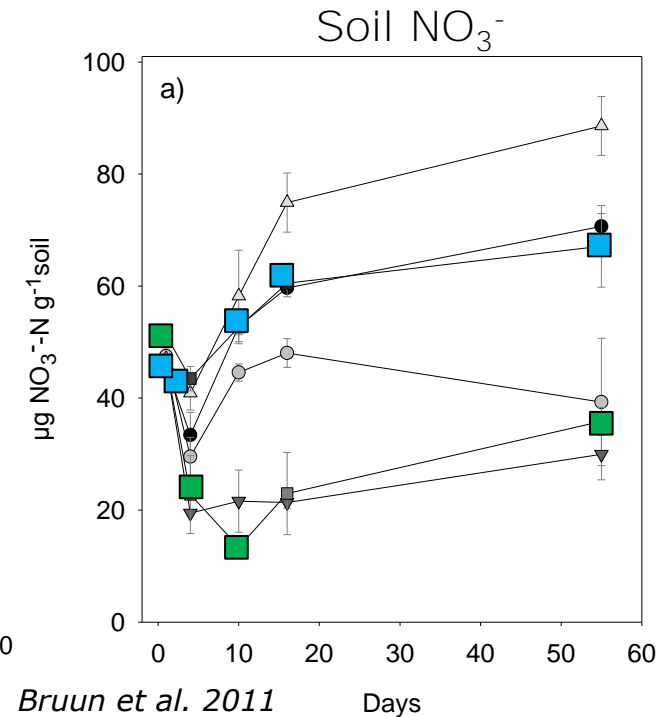
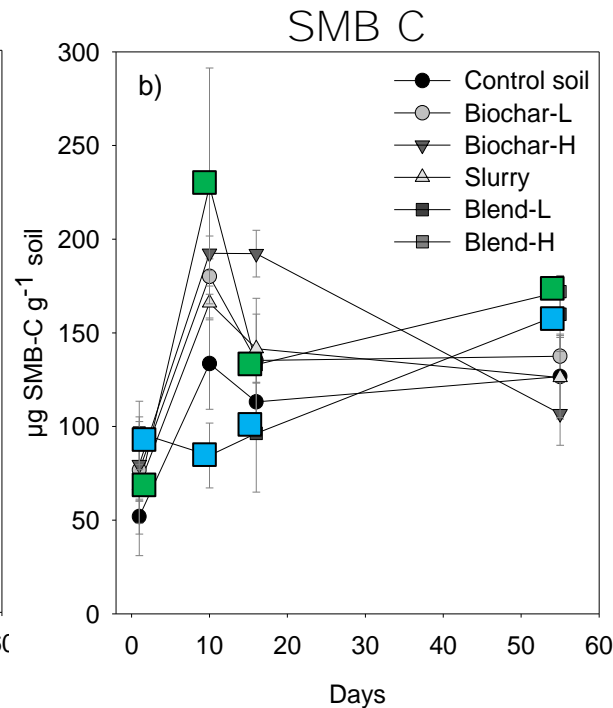
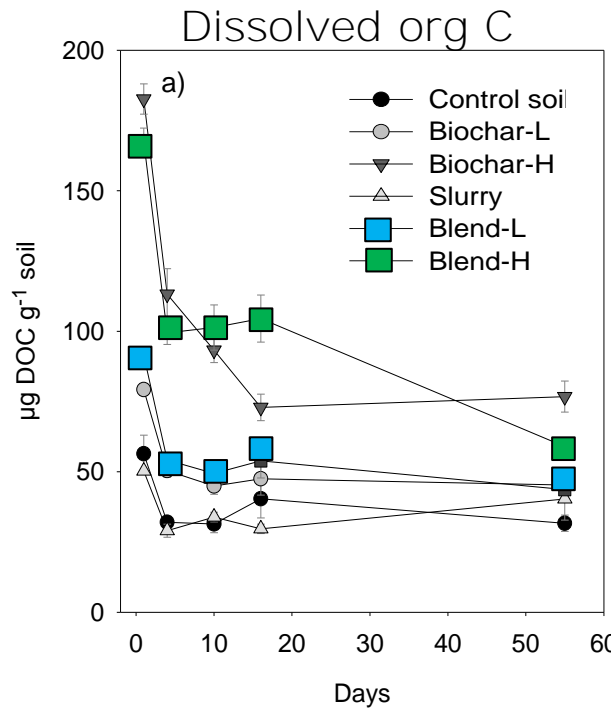
1. Soil; ('con
2. + 1% bio
3. + 3% bio
4. + slurry ;
5. + slurry +
6. + slurry +

80% WFPS, Sl





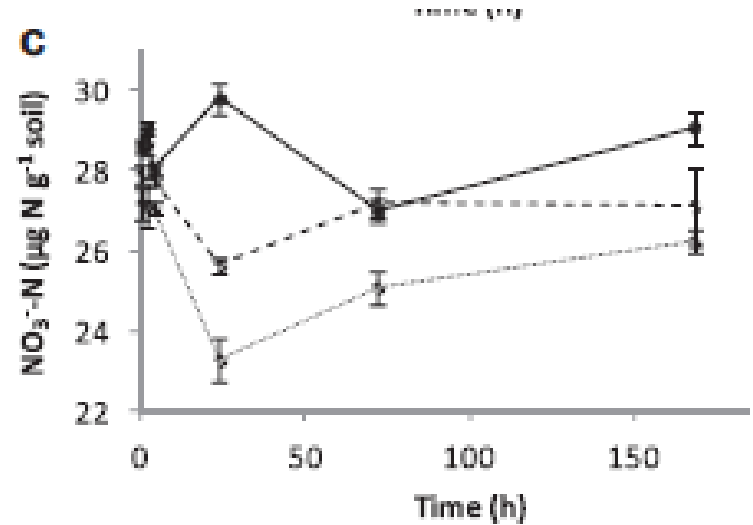
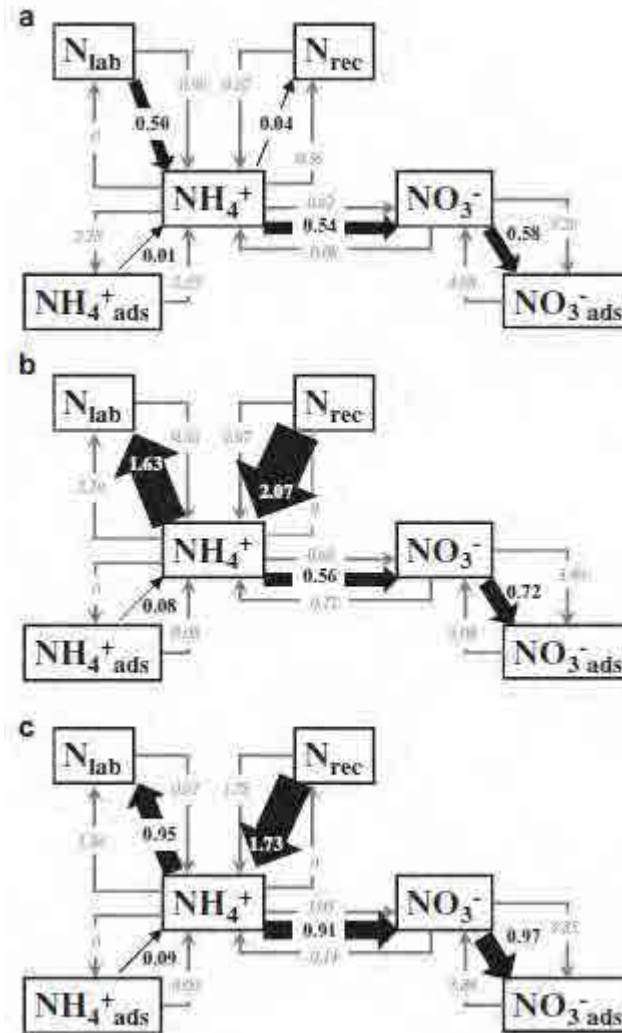
# What caused the reduced N<sub>2</sub>O with addition of biochar to slurry?



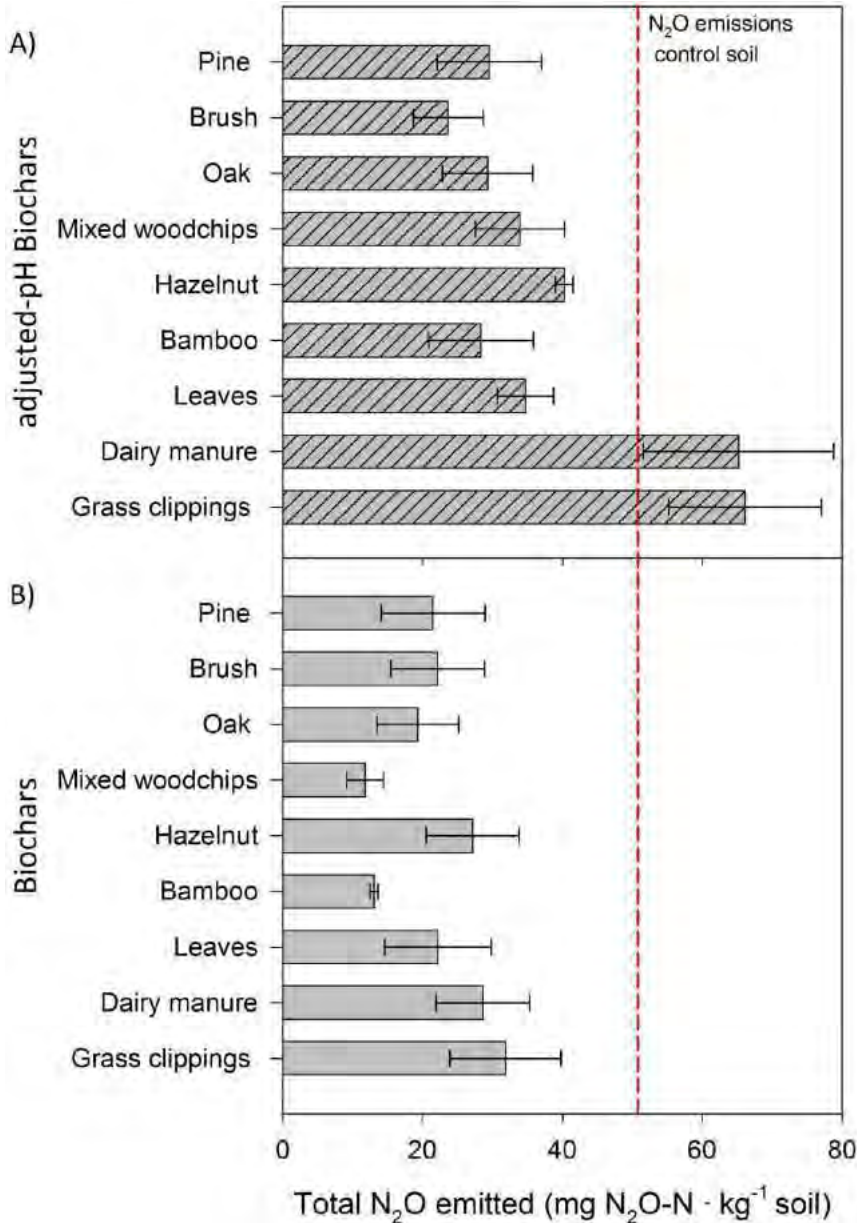
Bruun et al. 2011



# Increased net adsorption of soil $\text{NO}_3^-$



*Nelissen et al. 2012*



**BC increases pH**

**Reduction of the N<sub>2</sub>O/(N<sub>2</sub>+N<sub>2</sub>O) ratio**

**Biochar acid buffer capacity was identified as an important aspect for mitigation**

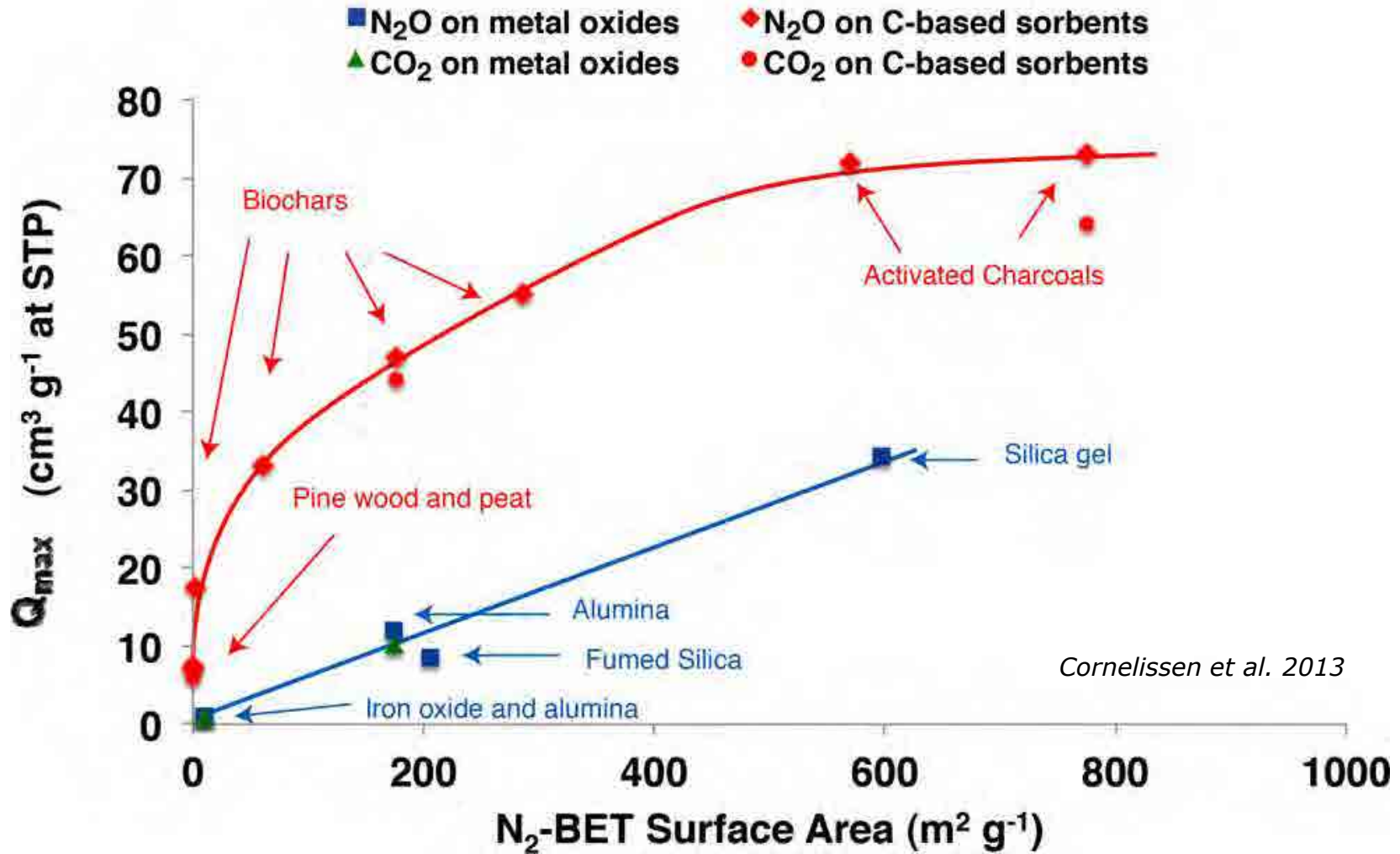
**not primarily caused by a pH shift in soil**

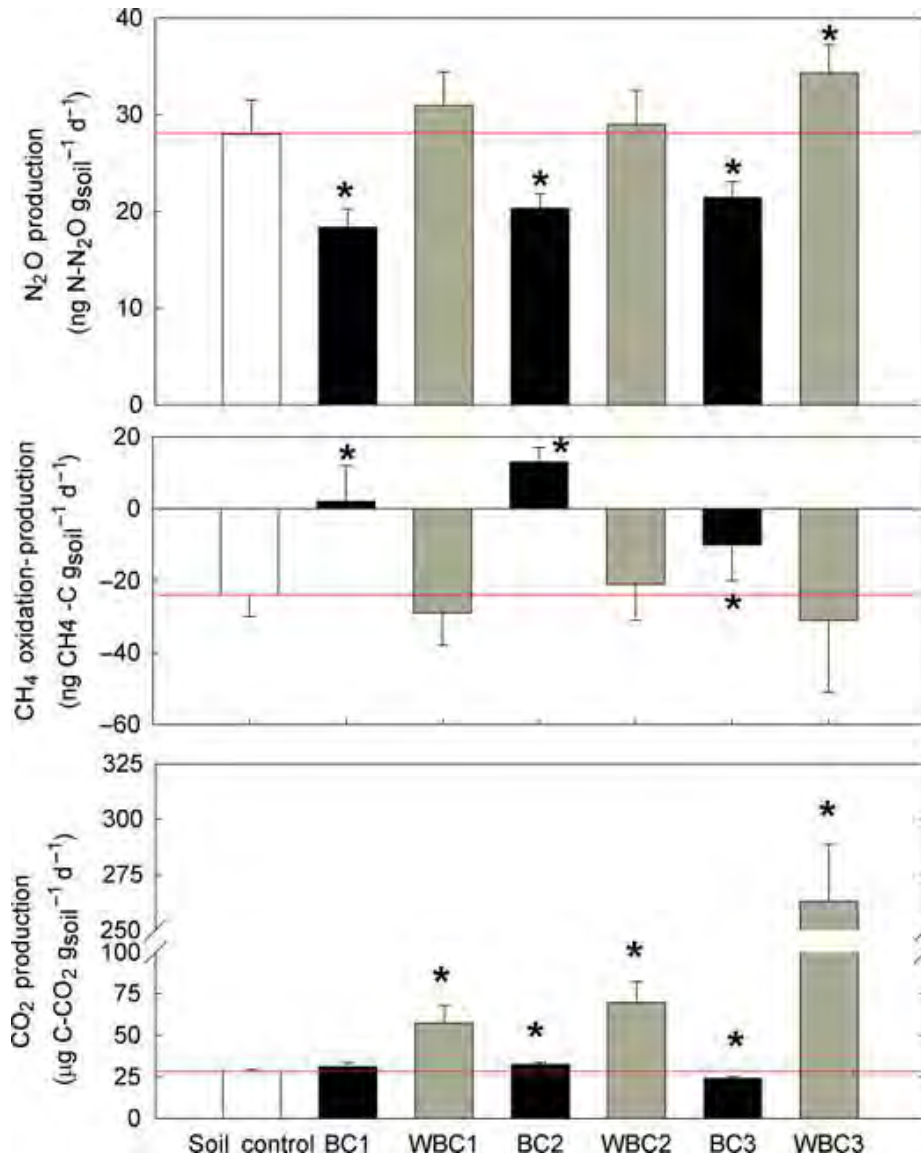
**'electron shuffle' effect**

*Cayuela et al. 2013*



## $Q_{\max}$ (20 °C) for $N_2O$ and $CO_2$ sorption





## Age is important

**Aging negates the biochar effect**



*Spokas 2013*



## Majority of studies show decreased N<sub>2</sub>O emission with BC

### A universal conclusion cannot be reached

what makes a biochar able to mitigate N<sub>2</sub>O emissions  
what type of char/feedstock  
management

#### **Nitrogen** availability

- Adsorption-desorption; N-source; N-mineralization

#### Organic **carbon** availability

- Labile components

#### **Oxygen** availability

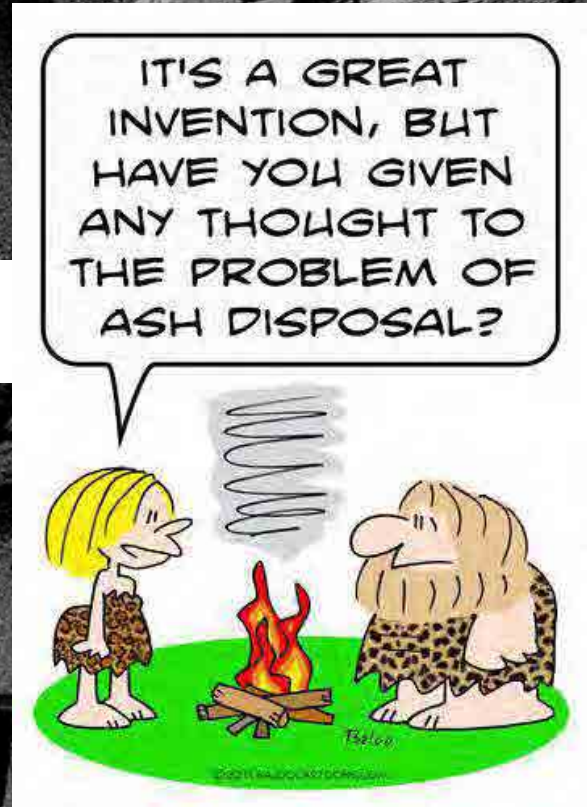
- Soil texture, soil WHC; biological activity

#### **Physio-chemical** environment

- pH, temperature



**Thanks for your attention!**







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ALLIANCE

ON AGRICULTURAL GREENHOUSE GASES



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17-19 March 2014  
PARIS



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# Short presentation

Simulating the impacts of management practices on  
nitrous oxide emissions from cropland soils

Mohamed Abdalla<sup>1,2</sup>, Pete Smith<sup>1</sup>, Mike Williams<sup>2</sup> and  
Mike Jones<sup>2</sup>

<sup>1</sup>Institute of Biological and Environmental Sciences, School of Biological Sciences, University of Aberdeen,  
Aberdeen, UK

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17-19 March 2014  
PARIS

Workshop "Experimental databases and model of N<sub>2</sub>O emissions by croplands:  
do we have what is needed to explore mitigation options?"



## objectives

- To investigate the effectiveness of different management systems to mitigate nitrous oxide emissions from arable system.
  - i- Effectiveness of Reduced N
  - ii- Effectiveness of Reduced tillage
  - iii- Effectiveness of Reduced tillage-Cover crop



## Materials & Methods

Field management dates for conventional and reduced tillage/cover crop systems during the experimental period.

Operation	Treatment date (day/month)	
	Reduced tillage-cover crop	Conventional tillage
Ploughing	18-27/8	18-25/2
Sowing	9-19/3	9-19/3
Fertilizer application	13-21/4 & 7-22/5	13-21/4 & 7-22/5
Sowing cover crop	8/8-13/9	-
Harvesting	5-21/8	5-21/8



# Results

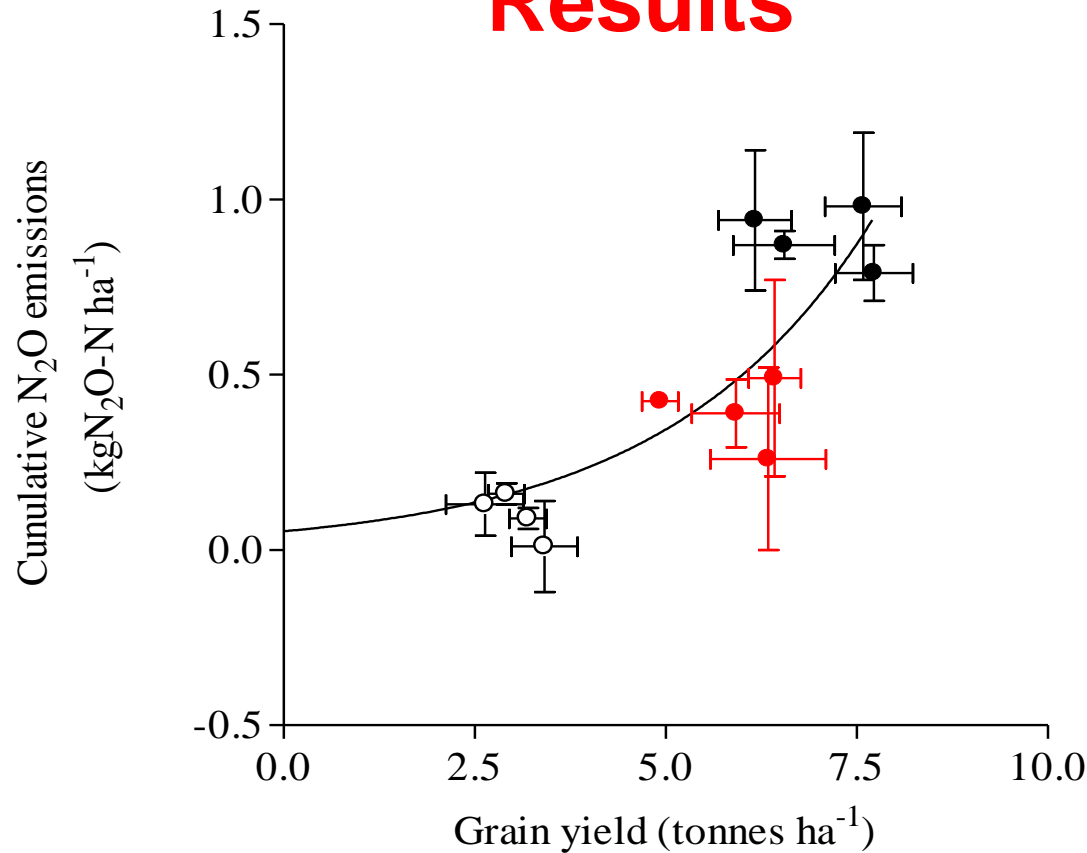
N <sub>2</sub> O emissions ( kg N <sub>2</sub> O-N ha <sup>-1</sup> )				Rd (%)
First year	Treatment	Observation	Model	
Conventional tillage	140 kg N ha <sup>-1</sup>	0.788 a	0.780	-1
	70 kg N ha <sup>-1</sup>	0.269 b	0.350	+30
	0 kg N ha <sup>-1</sup>	0.002 c	0.110	+ >100
Reduced tillage	140 kg N ha <sup>-1</sup>	0.978 a	0.590	-40
	70 kg N ha <sup>-1</sup>	0.494 b	0.220	-55
	0 kg N ha <sup>-1</sup>	0.087 c	0.030	-66
Second year				
Conventional tillage	160 kg N ha <sup>-1</sup>	1.053 a	0.993	-6
	80 kg N ha <sup>-1</sup>	0.563 b	0.450	-20
	0 kg N ha <sup>-1</sup>	0.170 c	0.110	-35
Reduced tillage	160 kg N ha <sup>-1</sup>	1.058 a	0.793	-25
	80 kg N ha <sup>-1</sup>	0.567 b	0.320	-44
	0 kg N ha <sup>-1</sup>	0.135 c	0.010	-93

• Measured EFs: 0.4 to 0.7%, whilst modeled EFs: 0.3 to 0.6%

Abdalla et al. (2009)



## Results



- Exponential correlation:  $y = 0.053 * e^{0.373x}$ , ( $r^2 = 0.69$ ).
- Reducing the applied nitrogen fertilizer by 50 % reduce N<sub>2</sub>O emissions by 57 % but only 16% of grain yield.



# Results

Table: Observed and simulated cumulative N<sub>2</sub>O from RT-CC and CT over the experimental period.

Treatment	Cumulative N <sub>2</sub> O emission (kg N ha <sup>-1</sup> )		
	Observation	Model	Relative deviation (%)
<b>Reduced tillage–cover crop</b>			
140 kg N ha <sup>-1</sup>	2.42 a	1.56	–36
70 kg N ha <sup>-1</sup>	2.17 a	0.91	–58
0 kg N ha <sup>-1</sup>	0.87 b	0.76	–13
<b>Conventional tillage</b>			
140 kg N ha <sup>-1</sup>	1.74 a	1.41	–19
70 kg N ha <sup>-1</sup>	1.37 a	1.01	–26
0 kg N ha <sup>-1</sup>	0.86 b	1.00	+16

Different letters are significantly different from each other ( $p < 0.05$ )



## Results

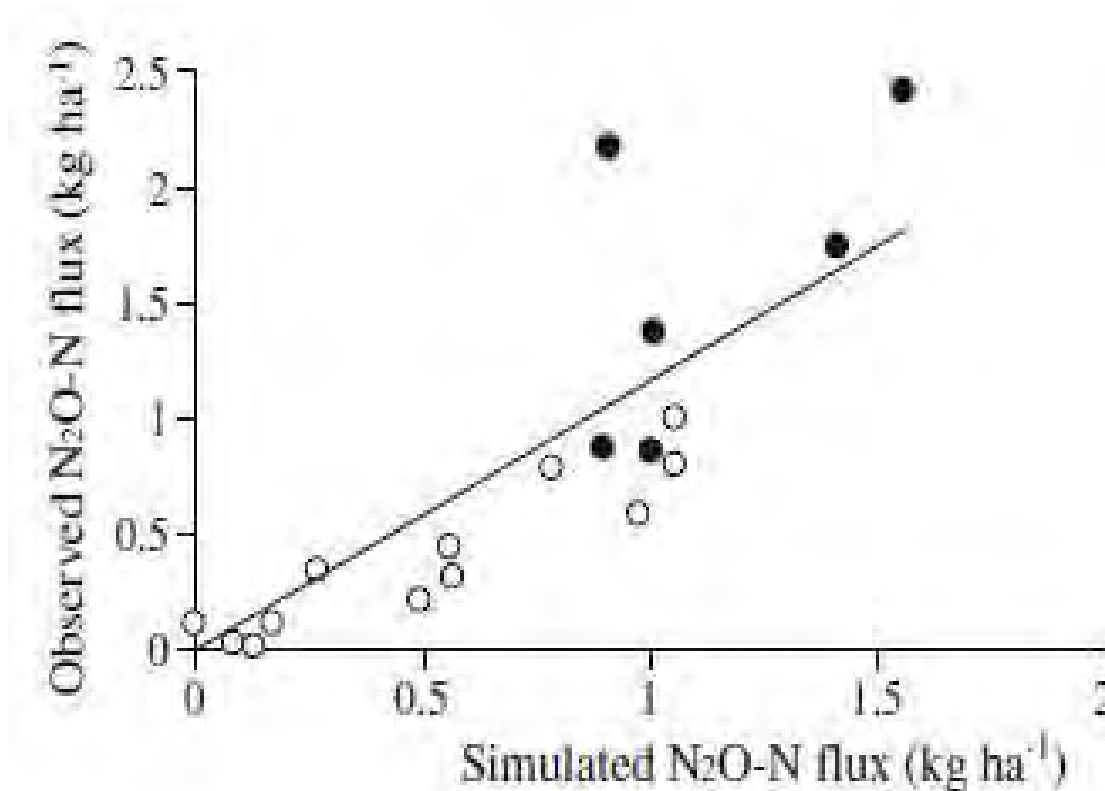


Fig.: Linear regression relationship between the model simulated and observed cumulative N<sub>2</sub>O fluxes. Data of the reduced and conventional tillage plots from this study (filled circles) and from Abdalla et al. (2009) (open circles) were pooled together,  $y = 1.2x$  and  $r^2 = 0.70$





## Results

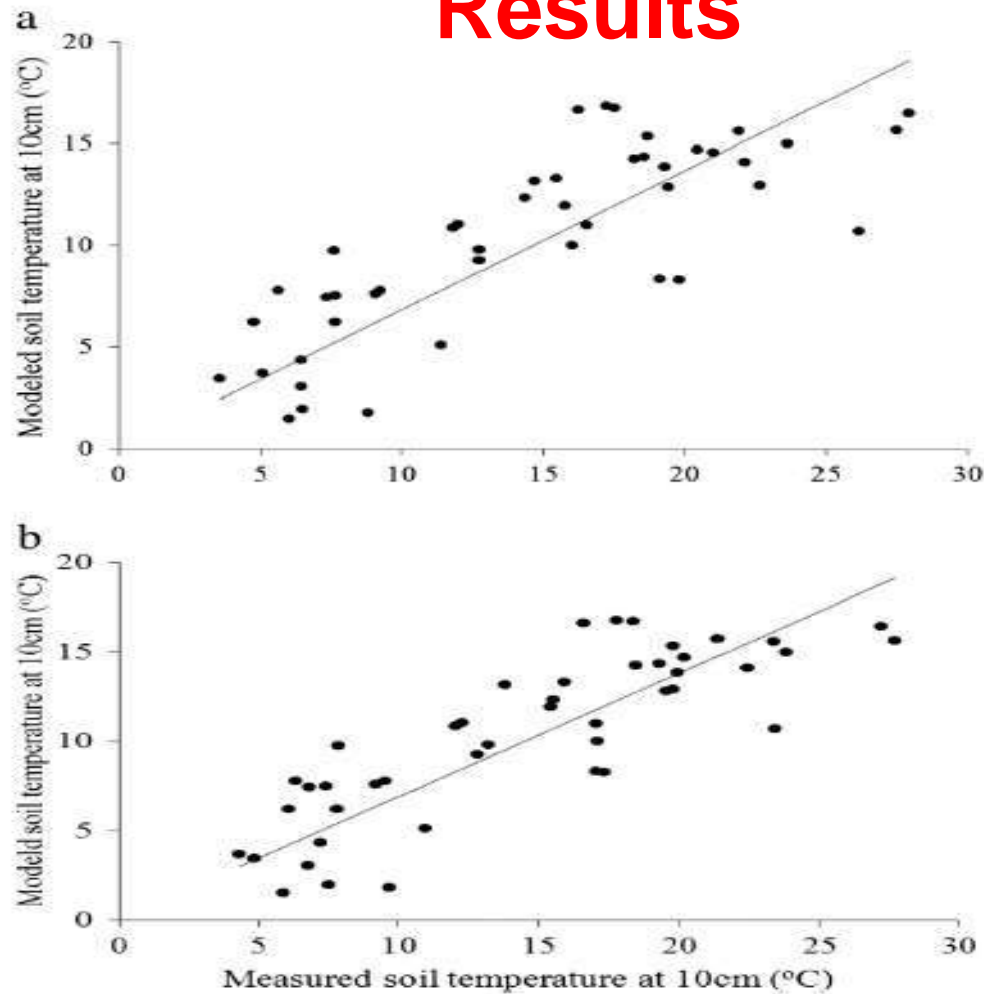


Fig.: Regression relationships (1:1) between the field daily mean measured and DNDC simulated soil temperature (10 cm depth) from the conventional (a;  $y = 0.5x + 2.4$  and  $r^2 = 0.65$ ) and reduced tillage/cover crop (b;  $y = 0.6x + 1.7$  and  $r^2 = 0.7$ ).



# Results

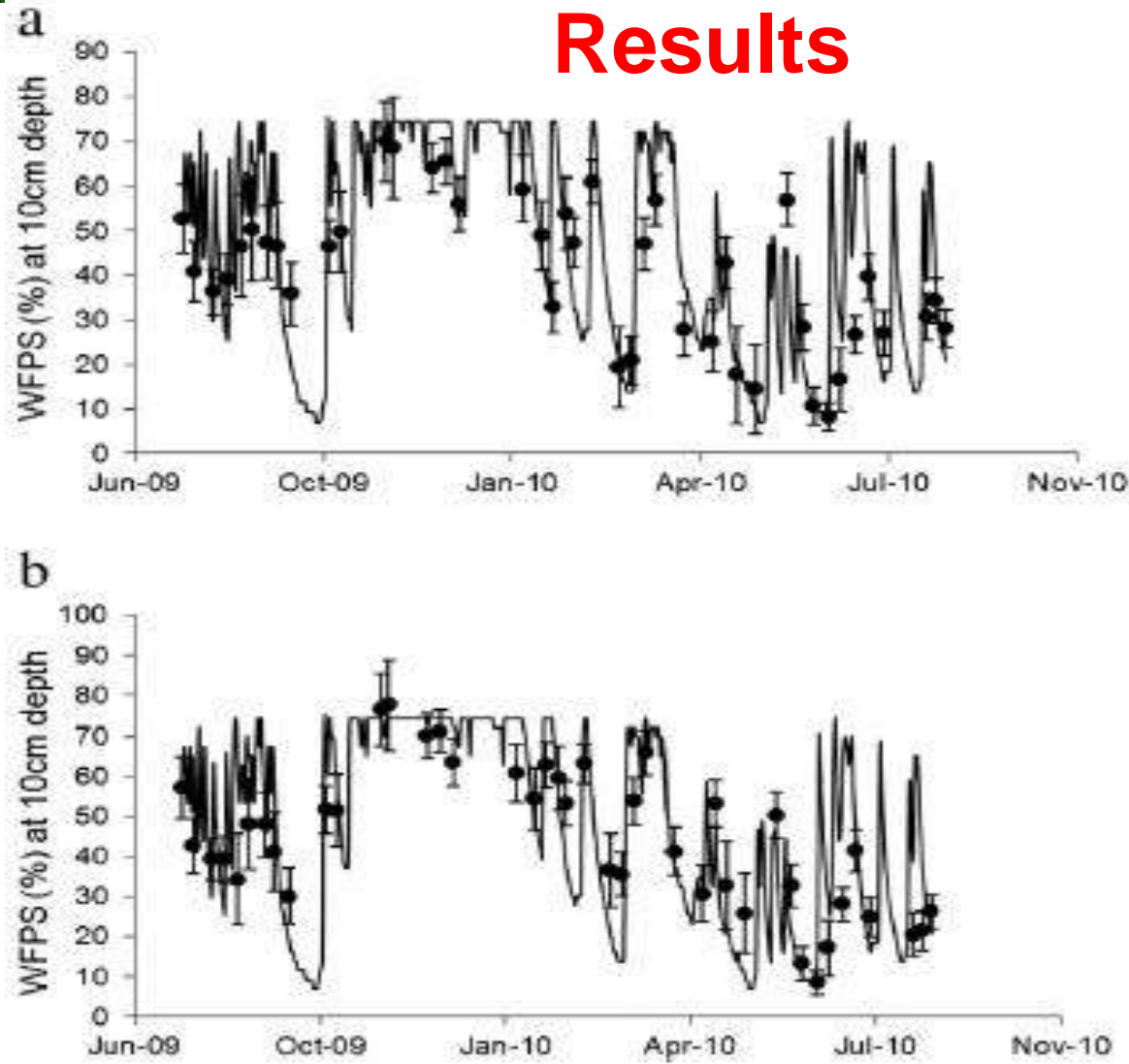


Fig.: Comparison between the DNDC simulated (lines) and field measured soil (●)WFPS (10 cm depth) from the conventional (a) and reduced tillage/cover crop (b). Error bars for measured values are  $\pm$ standard deviation.



# Results

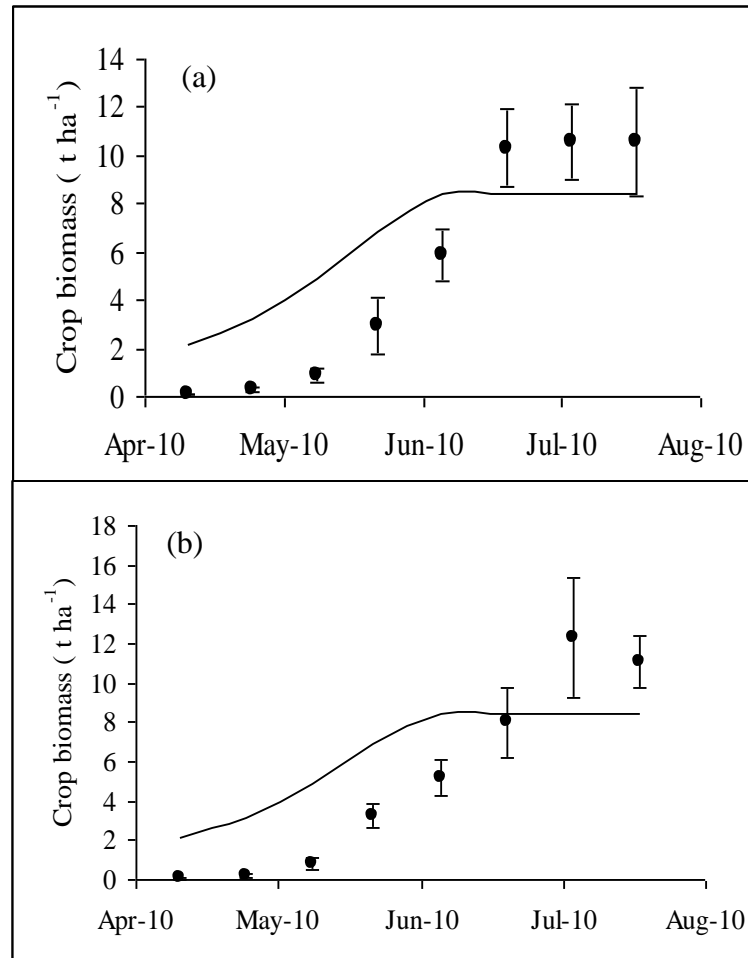


Fig.: Comparisons between the DNDC simulated (lines) and field measured (●) crop biomass from the conventional (a) and reduced tillage/ cover crop systems (b).



## Results

Table: Comparisons between measured and simulated N<sub>2</sub>O fluxes, biomass production (t C ha<sup>-1</sup>), average soil nitrate, temperature and WFPS (at 10 cm depth) for the CT and RT-CC. For column, values with different letters for the same gas are significantly different from each other (P<0.05).

<i>Management System</i>	<i>Annual N<sub>2</sub>O fluxes (kg ha<sup>-1</sup>), biomass production (t ha<sup>-1</sup>) and average soil nitrate (kg ha<sup>-1</sup>), temperature (° C) and WFPS (%).</i>					
	<i>Measured</i>	<i>Modelled</i>	<i>RD</i>	<i>RMSE</i>	<i>MAE</i>	<i>r<sup>2</sup></i>
<b>Conventional tillage</b>						
N <sub>2</sub> O	3.8 a	0.96	75	0.01	0.0	0.01
Crop biomass (C)	4.2	4.0	- 6	0.8	1.7	0.29
Soil nitrate	19.2	52	+>100	8.0	29	0.52
Soil temperature	14.5	11.7	-20	0.9	-4.5	0.65
WFPS	43	45	+3	2.0	0.9	0.64
<b>Reduced tillage/ cover crop</b>						
N <sub>2</sub> O	5.3 b	1.1	77	0.0	0.0	0.01
Crop biomass (C)	4.4	4.0	-10	0.8	1.7	0.26
Soil nitrate	23.0	31.6	+37	5.0	23.0	0.39
Soil temperature	14.6	11.7	-19	0.8	-4.5	0.70
WFPS	44	45	+1	2.0	0.4	0.61



## Conclusions

- The DNDC model can be successfully applied to estimate  $N_2O$  emissions under different management systems however, some model-limitations need to be addressed.
- Reducing N fertilizer by 50% is an acceptable strategy for low input agriculture in that there was no significant effect on grain yield or quality.
- The use of RT-CC as an alternative farm management system for spring barley, if the sole objective is to reduce  $N_2O$  emissions, may not be successful.

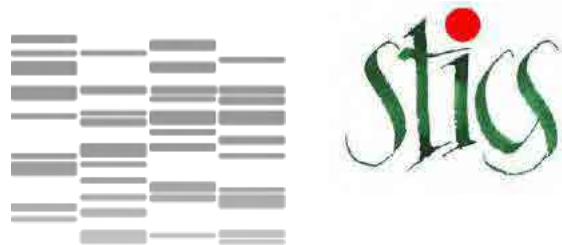


# Short presentation

Simulation of the effect of some management practices on N<sub>2</sub>O emissions using the STICS model  
(preliminary results)

Joël Leonard

N. Brunet, C. Gaudnik, E. Gréhan, B. Mary, C.  
Peyrard



# soil-crop model

## ■ Main variables simulated

- ❖ **Crop growth** (with generic crop representation); dynamics of **water, nitrogen, carbon** in plant and soil

## ■ Management practices

- ❖ **Complex rotations**: cover crops, intercropping, leguminous crops; possible to connect sequences
- ❖ **N inputs** (mineral, organic): amount, form, depth, timing ; **crop residues** restitution/exportation
- ❖ **Soil tillage**/soil structure (mixing, compaction), mulch effect
- ❖ Irrigation, drainage/saturation

## ■ N<sub>2</sub>O

- ❖ **Nitrification** and **denitrification**
- ❖ **N<sub>2</sub>O emissions** associated to both processes
- ❖ Approach: **potential modulated by substrate availability** (NO<sub>3</sub>, NH<sub>4</sub>) and **environment** (T, water and O<sub>2</sub> via WFPS, pH) (Bessou et al., EJSS, 2010)

# Field experiment

'SOERE ACBB', arable crops site, Estrées-Mons, France

- Some of the main practices used to reduce the environmental impacts of cropping systems are represented

- » Reduction of tillage
- » Residues management
- » Reduction of nitrogen inputs
- » Cover crops / leguminous crops

## Possible comparisons of treatments by pairs

	Experimental Treatment	Crop Rotation	Soil Tillage	Crop residues	Nitrogen inputs	Cover crop
T1	Conventional tillage	Spring Peas, Winter Rapeseed, Winter Wheat, Spring Barley, Corn, Winter Wheat	Conventional	Straw Incorporation	Integrated production	Non legume
T2	Reduced tillage	Spring Peas, Winter Rapeseed, Winter Wheat, Spring Barley, Corn, Winter Wheat	Reduced	Straw Incorporation	Integrated production	Non legume
T3	Reduced tillage & Straw exportation	Spring Peas, Winter Rapeseed, Winter Wheat, Spring Barley, Corn, Winter Wheat	Reduced	Straw Removal	Integrated production	Non legume
T4	Low Nitrogen Inputs	Spring Peas, Winter Rapeseed, Winter Wheat, Spring Barley, Corn, Winter Wheat	Conventional	Straw Incorporation	Low Mineral Inputs	Non legume
T5	Ecological Intensification	Spring Peas, Winter Rapeseed, Winter Wheat, Spring Barley, Corn, Winter Wheat	Conventional	Straw Incorporation	Low Mineral Inputs	Legume
T6	Integration of biomass crops	Switchgrass (duration : 8 years) Spring Peas, Winter Rapeseed, Winter Wheat, Spring Barley, Corn, Winter Wheat	Conventional	Straw Removal	Integrated production	Non legume





# N<sub>2</sub>O emissions

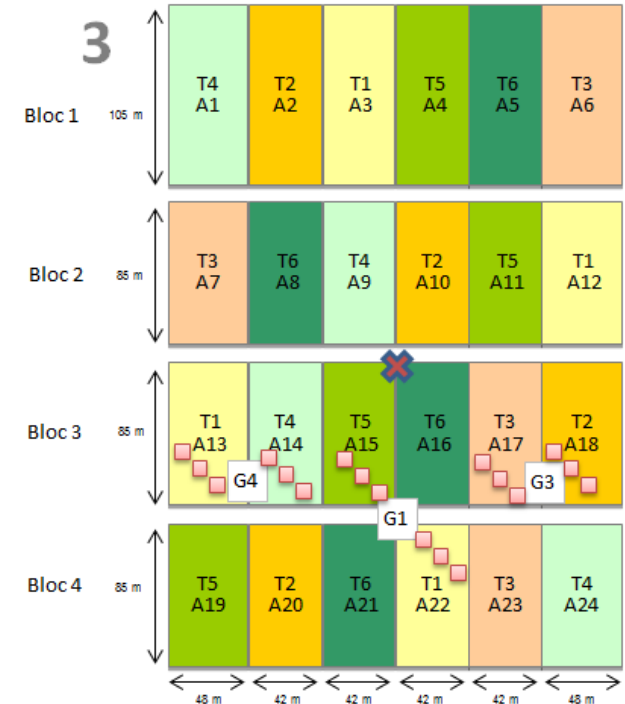
## ■ Continuous N<sub>2</sub>O measurements

- ❖ 3 Automatic chambers per plot, block replicate for one plot
- ❖ Rapeseed- Mustard - Barley 2011-2013 (603 days)



## ■ Measurements of soil nitrogen, soil water, soil temperature, biomass...

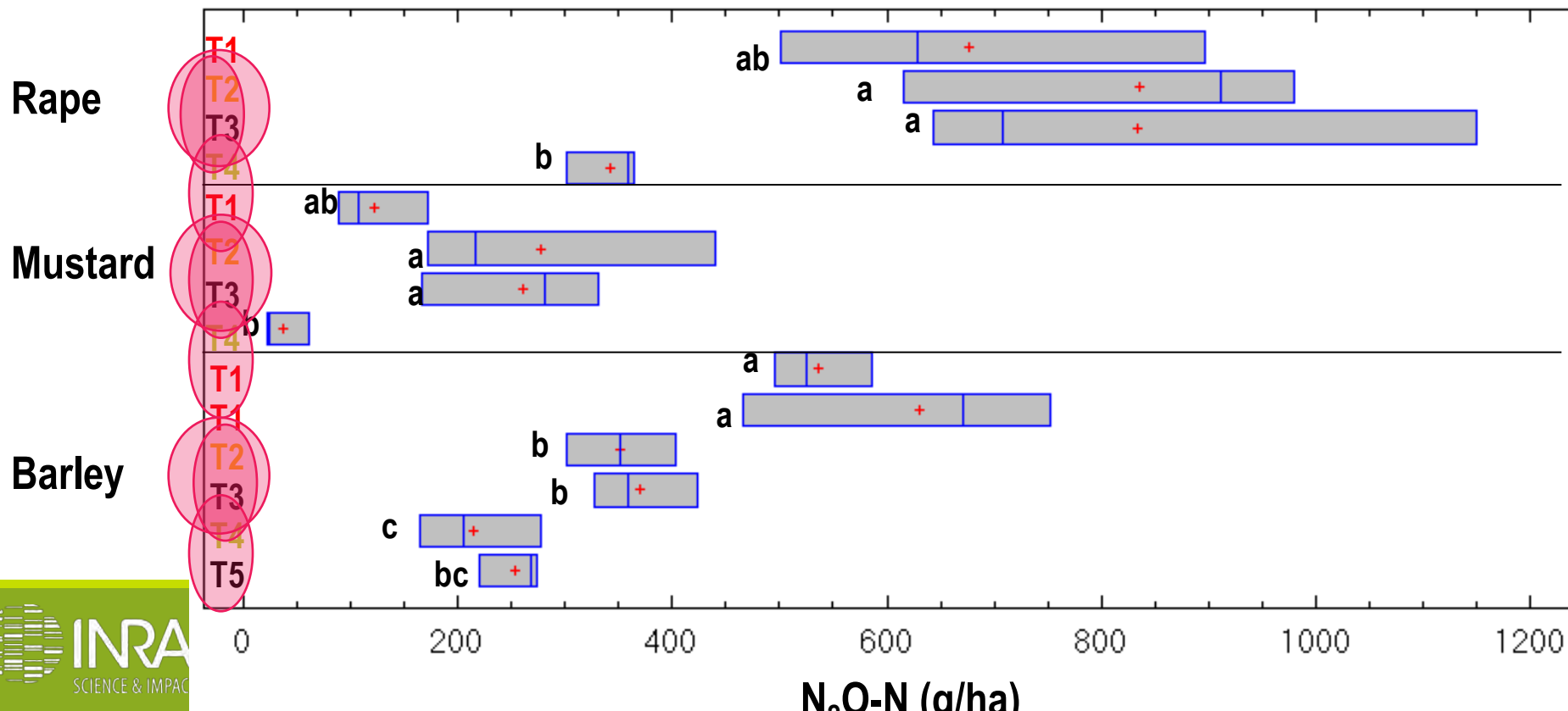
- ❖ Model initialization
- ❖ Model evaluation : check control variables



# Measured N<sub>2</sub>O emissions

- Contrasts between crops, but for part explained by varying crop cycle duration
- Reduction in fertilization is the major effect (T4 vs. T1)
- Reduced tillage effect variable (T2 vs. T1, consistent with other results)
- No effect of residues management (T3 removed vs. T2)

**T1 = reference system**



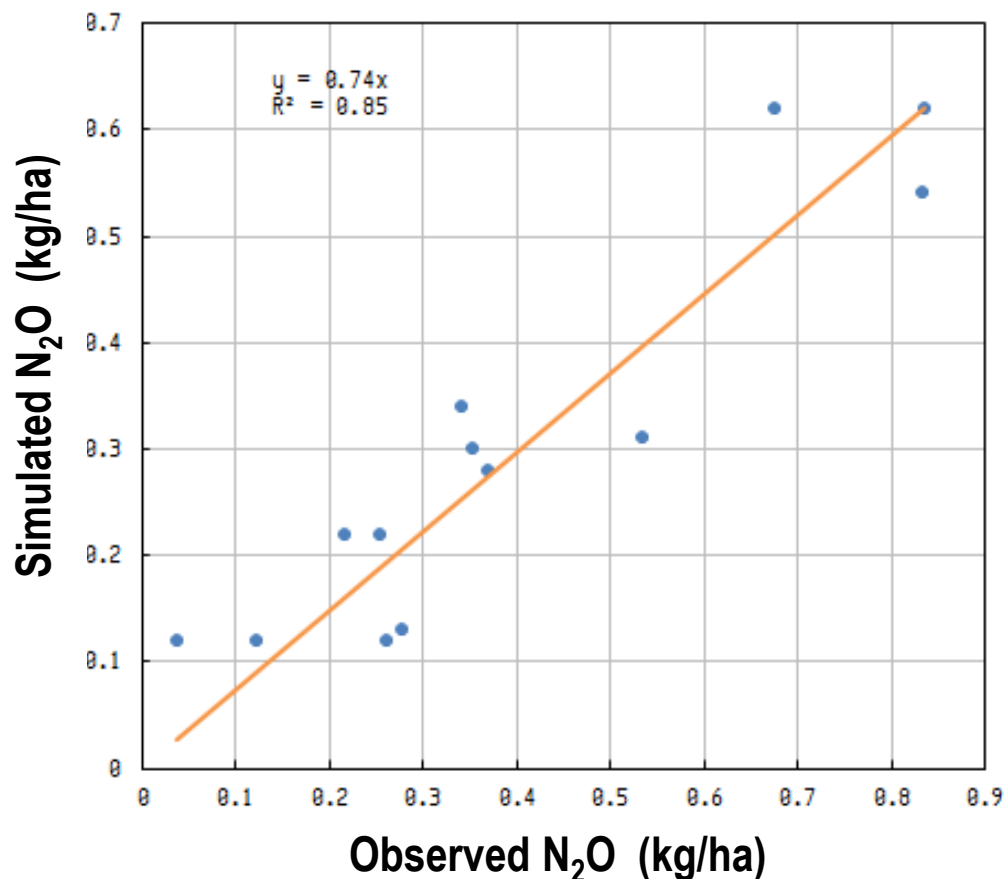
# Global model performances

No calibration

- Main variations captured
- Underestimation of simulated emissions

Nitrification supposed (from model results) to be the main source of N<sub>2</sub>O (77% of total)

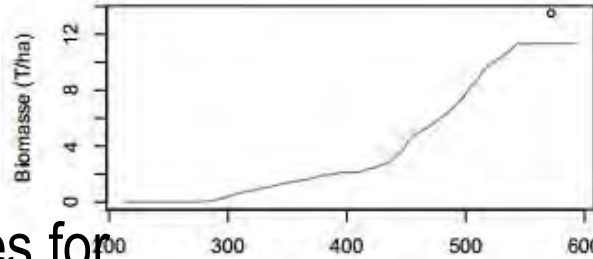
Cumulative observed and simulated N<sub>2</sub>O emissions, by treatment and crop



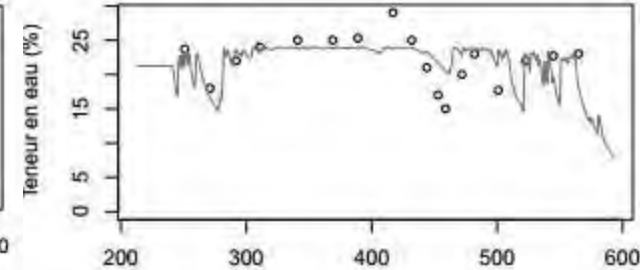
# Modelling N<sub>2</sub>O fluxes dynamics (ex. T1, rape)



Biomass

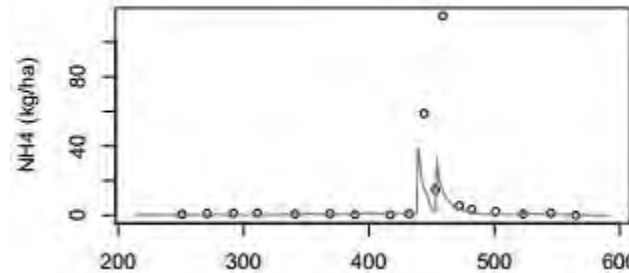


Water content

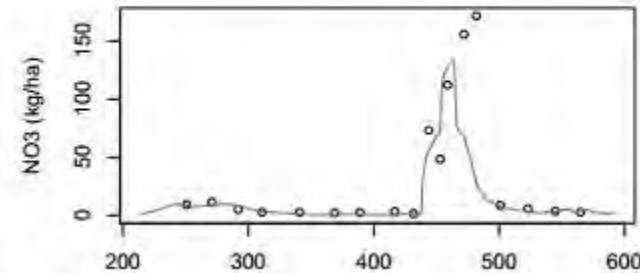


Reasonable performances for simulating control variables

NH<sub>4</sub>



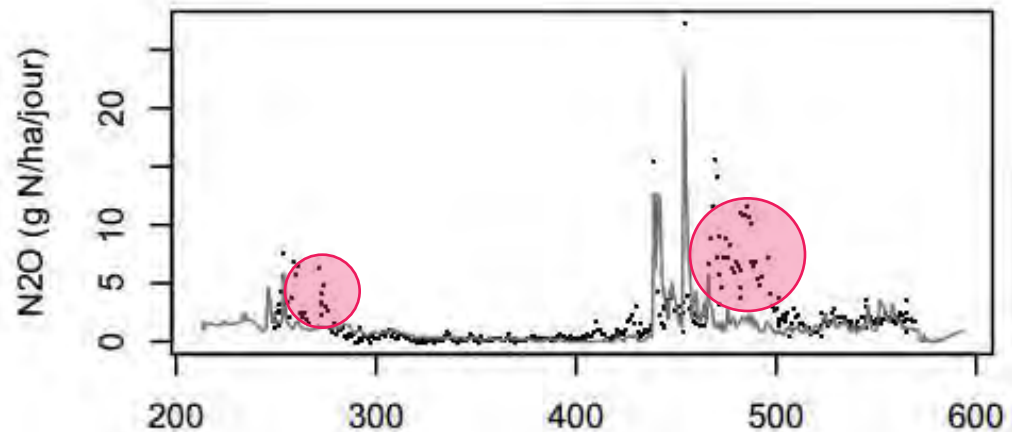
NO<sub>3</sub>



N<sub>2</sub>O :

- ❖ Correct order of magnitude of peaks
- ❖ Some but not all features of the temporal dynamics captured

N<sub>2</sub>O

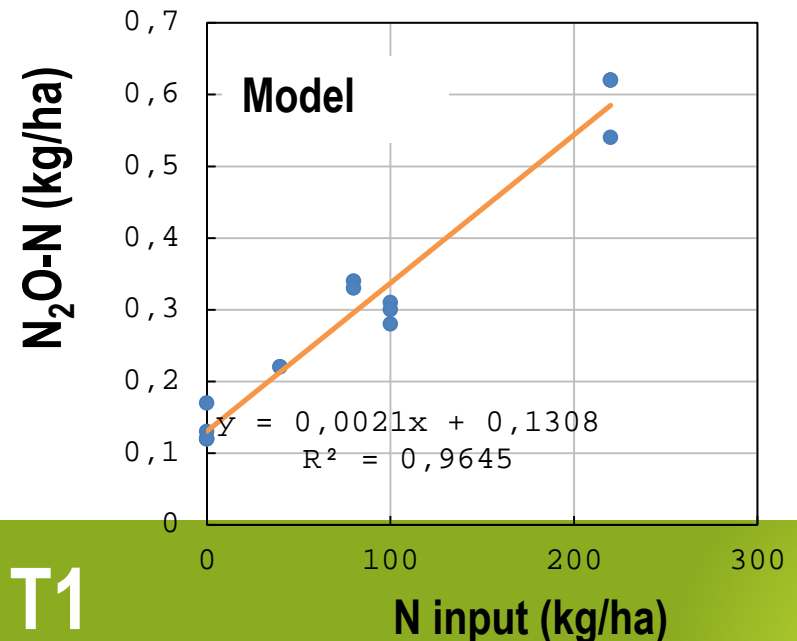
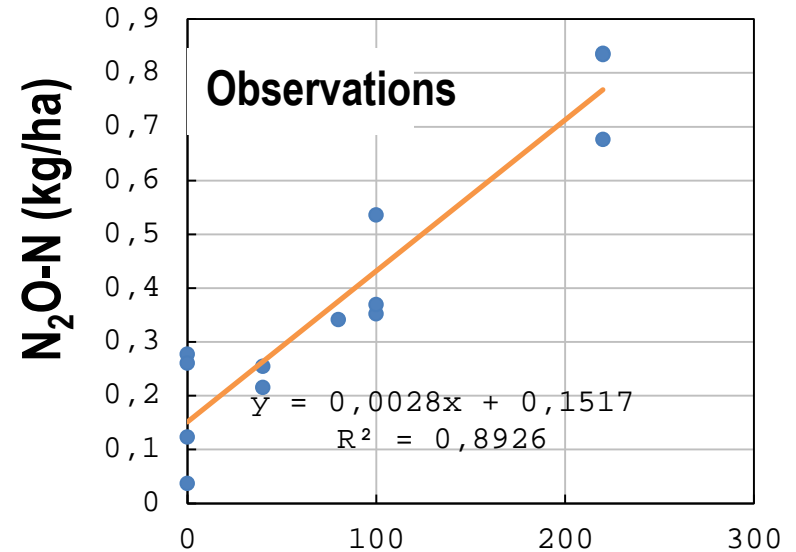
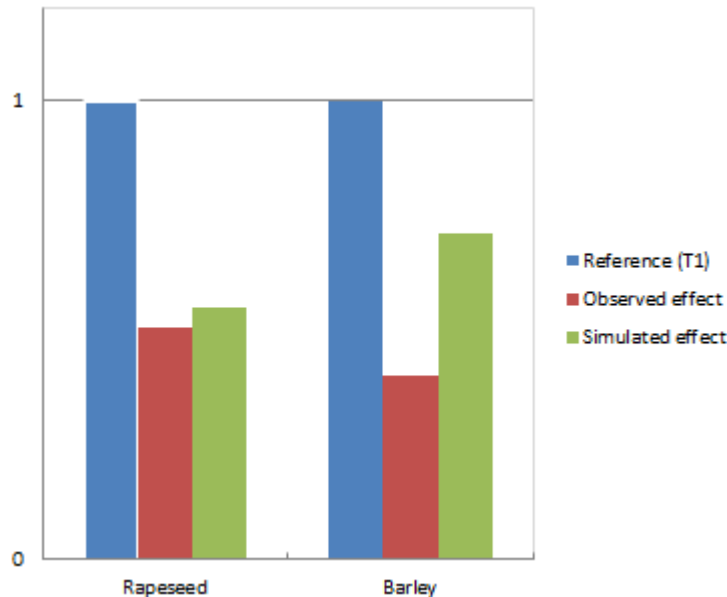


# Simulation of the effect of fertilization

- Correct order of magnitude: 0.21% N vs. 0.28% N << 1% IPCC

## ■ Relative effect

- ❖ Correct for rapeseed
- ❖ Underestimated for barley



T4 vs. T1

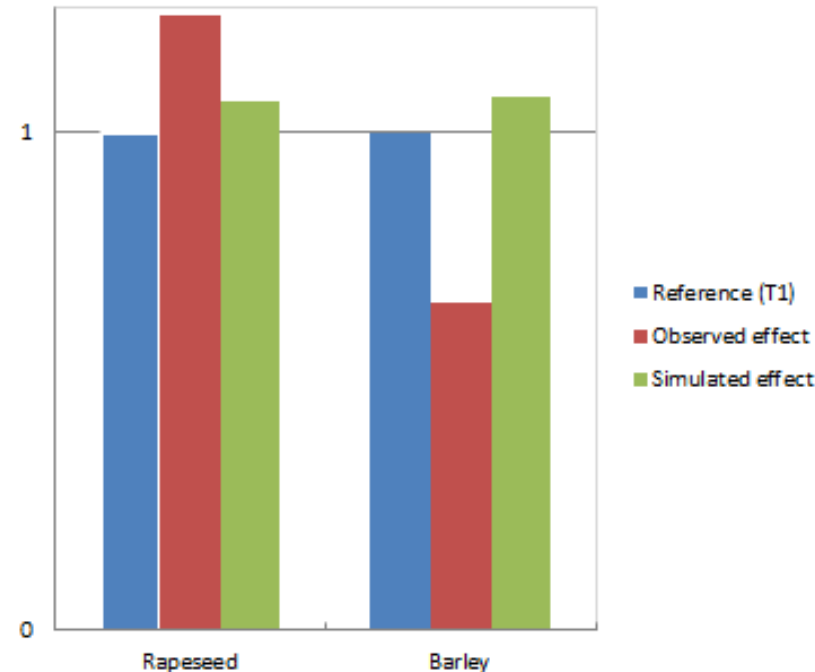
# Simulation of the effect of reduced tillage

## ■ Measured emissions

- ❖ a bit higher for rapeseed, **significantly lower for spring barley**
- ❖ Only **absence of ploughing on T2/T1**, same superficial tillage operations than on T1

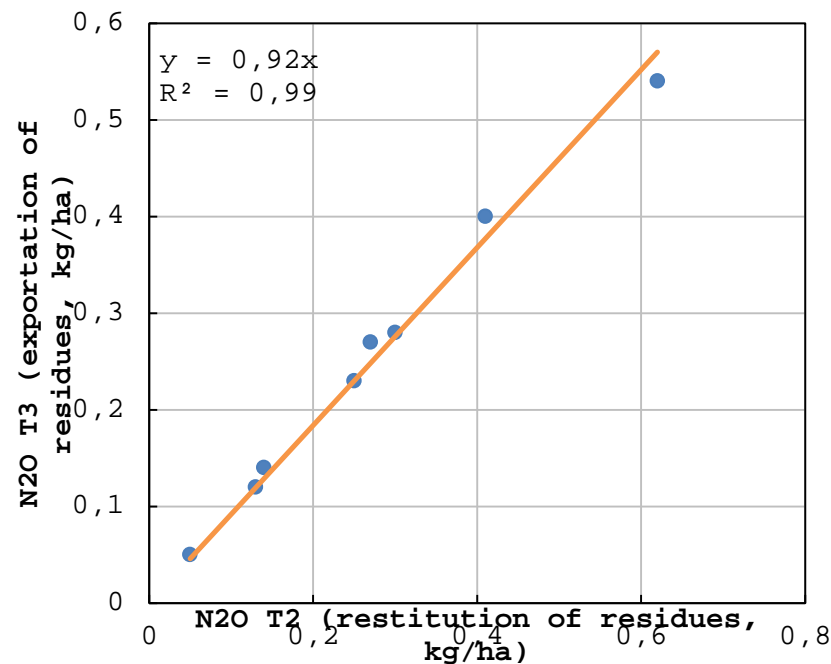
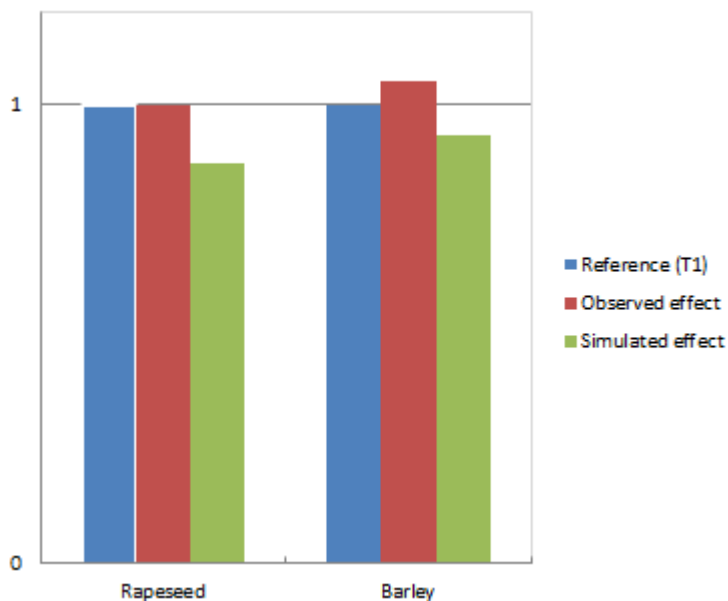
## ■ Modelled emissions:

- ❖ Slight increase in N<sub>2</sub>O emission **if small increase in soil bulk density taken into account**
- ❖ **No difference if the bulk density remains the same** (despite mixing effect of ploughing on mineral nitrogen concentration and water content)



# Simulation of the effect of crop residues restitution

- No significant difference for observed emissions
- Tendency to have slightly lower simulated emissions when residues are exported
  - ❖ -13 % on rapeseed following wheat with straw removed or not





# Some conclusions

- Observed differentiation between treatments is still limited after 3 years
    - ➔ Nitrogen input remains the main effect, rather small EF
    - ➔ Little differentiation in soil physical conditions
  - Reasonable performance of STICS (order of magnitude, dynamics) despite absence of calibration
  - Possible to simulate the effect of the different treatments, but :
    - ❖ more contrast between treatments for observed emissions than for simulated one
    - ❖ Simulations sometimes not consistent with observations (tillage)
- ➔ Useful to isolate the effect of a given practice, because poor simulation performance for this practice can be hid by another dominant practice such as N input





# Short presentation

Impacts of integrated weed management in cropping systems on N<sub>2</sub>O emissions from soil

A. Vermue, C. Hénault, A. Coffin, N. Munier-Jolain, B. Nicolardot





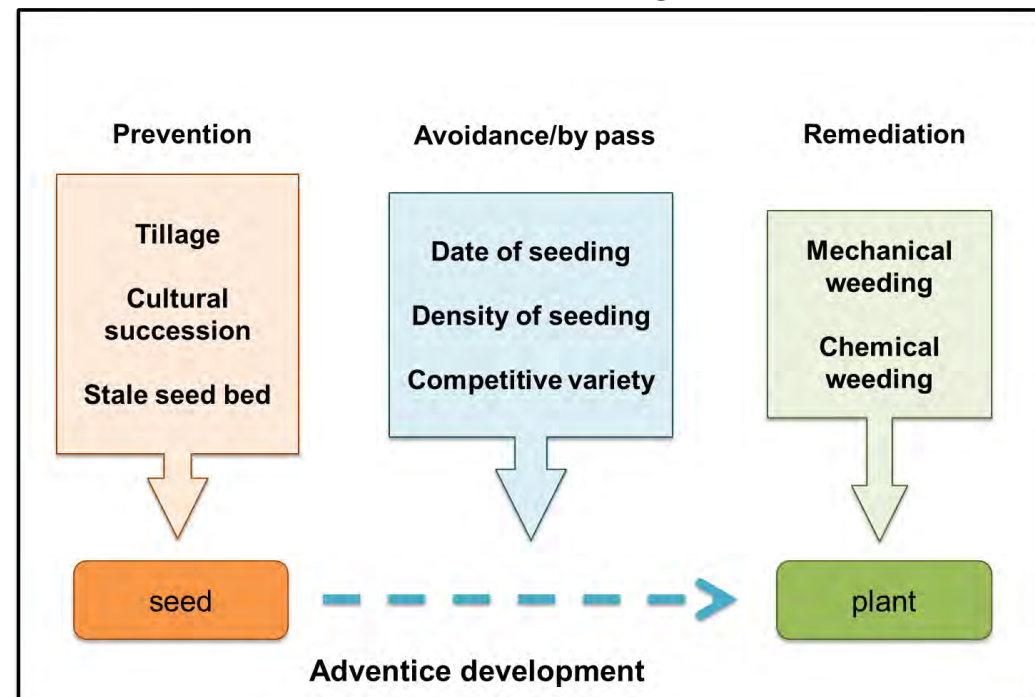
# Integrated Weed Management (IWM)

- **Definition**

To reduce the reliance of cropping systems on herbicide, with limited environmental, economic and social impacts

By the use of specific combinations of innovative agricultural practices

- **Means**





## Objectives of the study

- ⇒ To measure  $N_2O$  emission (together with ancillary variables) in cropping systems that includes some IWM systems
- ⇒ To analyse the collected databa with a modelling approach (NOE algorithm, Henault *et al.*, 2005)



# The Experimental Site

Eastern France (Dijon) – Semi-continental climate  
Calcisoil (with spatial heterogeneity)

IWM : started in 2000



Crop system	S1	S2	S3	S5
Type of system	Reference	IWM	IWM	IWM
Specific agricultural practices	Conventional	Minimum tillage (2000-2007) . No tillage from 2008 Plowing, harrowing, mechanical weeding excluded	Mechanical weeding excluded Tillage operation allowed when necessary	Mechanical weeding and plowing allowed
Treatment frequency index	2,4	2,0	1,4	0
Plowing frequency	1 / year	-	0.4 / year	0.5 / year
Crop Rotation	Wheat/barley/rape	diversified	diversified	diversified
Mean annual fertilisation (kg ha <sup>-1</sup> )	178	133	103	130



# Specific Field Measurements

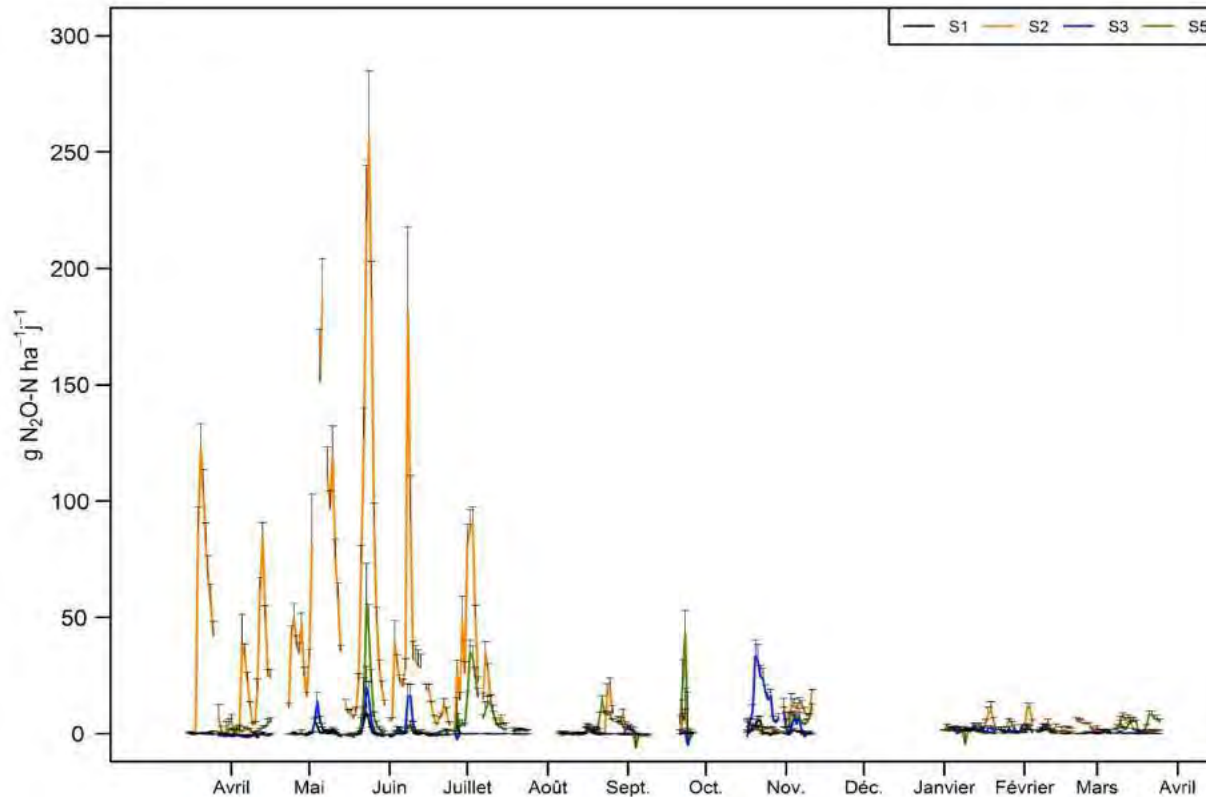
(April 2012 – April 2013)



- **6 automated chambers per plot coupled to IR analyser**
- **4 TDR and thermistor probes per plot**
- **Periodical measurements of nitrogen contents and of bulk density**



# Results of measurements



S1 – Conventional – wheat

S2 – IWM  
No tillage – herbicides - barley

S3 – IWM – reduced tillage – reduced herbicide - wheat

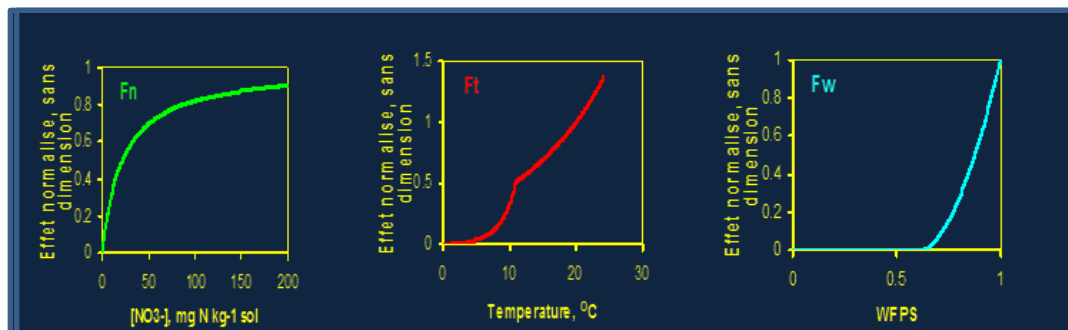
S5 – IWM zero herbicide alfafa

system	S1	S2	S3	S5
Mean flux (g N-N <sub>2</sub> O ha <sup>-1</sup> d <sup>-1</sup> )	0.5	26.8	1.8	3.7
Cumul (g N-N <sub>2</sub> O ha <sup>-1</sup> )	326 ± 168 <sup>c</sup>	5226 ± 670 <sup>a</sup>	177 ± 172 <sup>c</sup>	777 ± 177 <sup>b</sup>

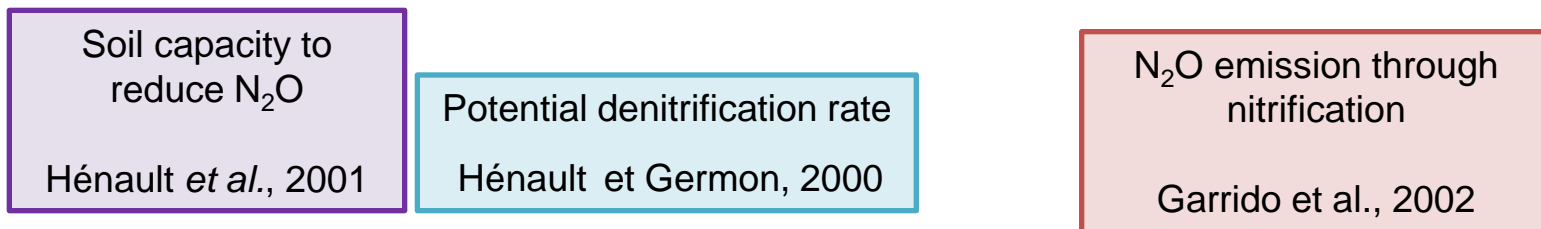
# The NOE Algorithm (Hénault et al., 2005)

## Environmental functions

- Temperature ( $F_T$ ,  $N_T$ )
- Soil moisture ( $F_W$ ,  $N_W$ )
- Soil nitrogen ( $F_{NO_3^-}$ ,  $N_{NH_4^+}$ )



## Biological parameters



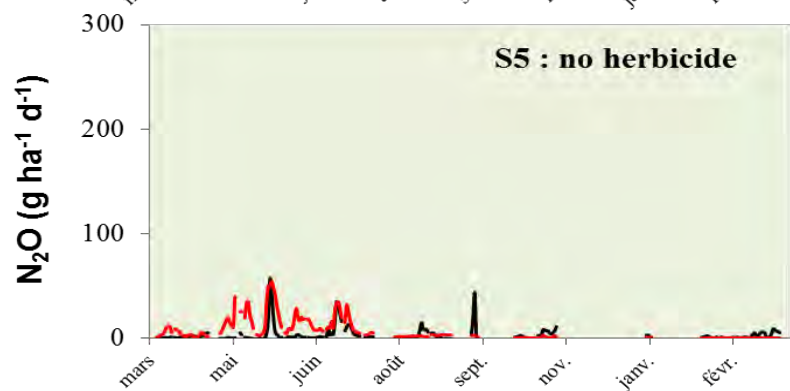
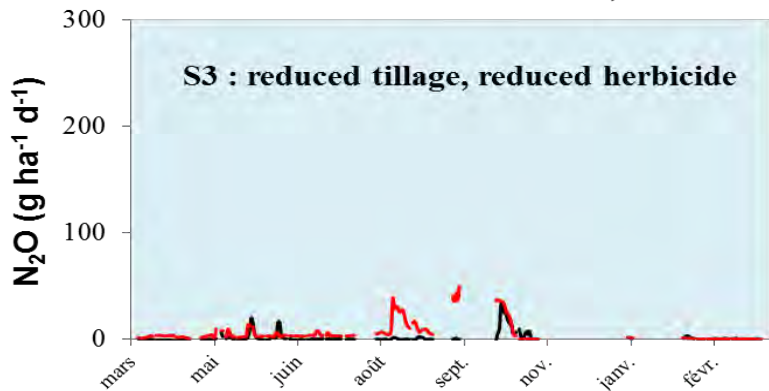
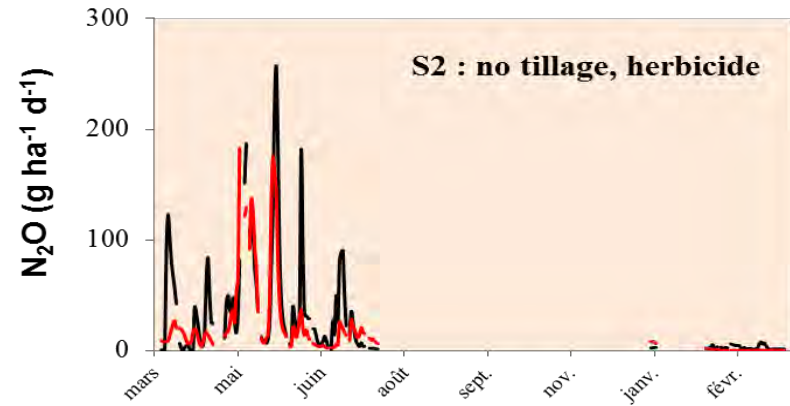
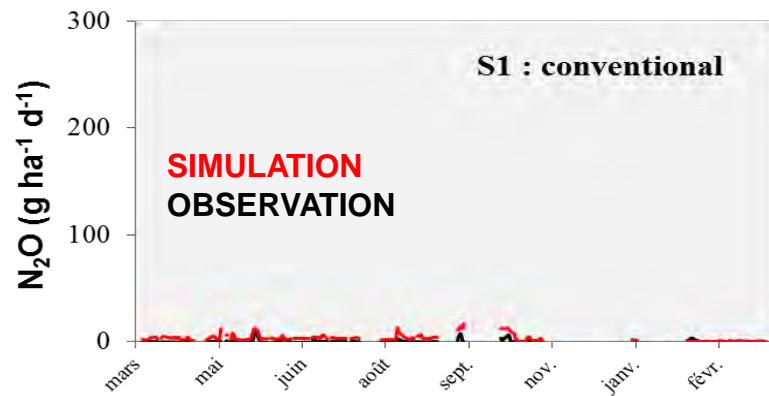
$$N_2O_{total} = R_{max} * (D_P * F_W * F_T * F_{NO_3^-}) + (z * N_W * N_T * N_{NH_4^+})$$

←
→
←
→

Denitrification Nitrification



# Results of simulations



system	S1	S2	S3	S5
observed cumul of emission (g N-N <sub>2</sub> O ha <sup>-1</sup> )	81	4672	328	756 <sup>b</sup>
Simulated cumul of emission (g N-N <sub>2</sub> O ha <sup>-1</sup> )	706	3209	1360	1596





## Main Conclusions

- ⇒ Impact of IWM system on the intensity of  $N_2O$  emission : higher  $N_2O$  emission in the « no-till » IWM system during 2012-2013 (more investigations are required because of (1) possible interactions between soil variability and IWM and (2) temporal effect))
- ⇒ The algorithm NOE was able to discriminate the  $N_2O$  emission intensity between the different IWM systems
- ⇒ The analysis using NOE suggests that higher emissions on the « no-till » IWM system are due to :
  - higher potential denitrification rate
  - higher soil WFPS (soil moisture, bulk density)



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# Short presentation

## Quantifying N-Emissions losses with Water and Nitrogen Management from Rice Paddy fields

Yam Kanta Gaihre

17-19 March 2014  
PARIS

Workshop "Experimental databases and model of N<sub>2</sub>O emissions by croplands:  
do we have what is needed to explore mitigation options?"

# Materials and Methods

- ❖ Water management
  - Continuous standing water (CSW)
  - Alternate wetting and drying (AWD)
  
- ❖ Nitrogen management
  - Surface broadcast (split application)
  - Urea deep placement (5-7 cm between 4 hills of rice at the alternate rows)

*Prilled Urea*

*Urea Briquettes*



# How Deep Placement Works?

Gaseous Loss

Negligible Ammonia Volatilization

Less  $N_2$ ,  $N_2O$ ,  $NO$

Negligible Floodwater Urea-N,  $NH_4^+$ -N,  $NO_3^-$ -N

Floodwater

Oxidized Soil Zone

10 cm

(Reduces Diffusion)

USG

$CO_2$

$NH_3$ -N

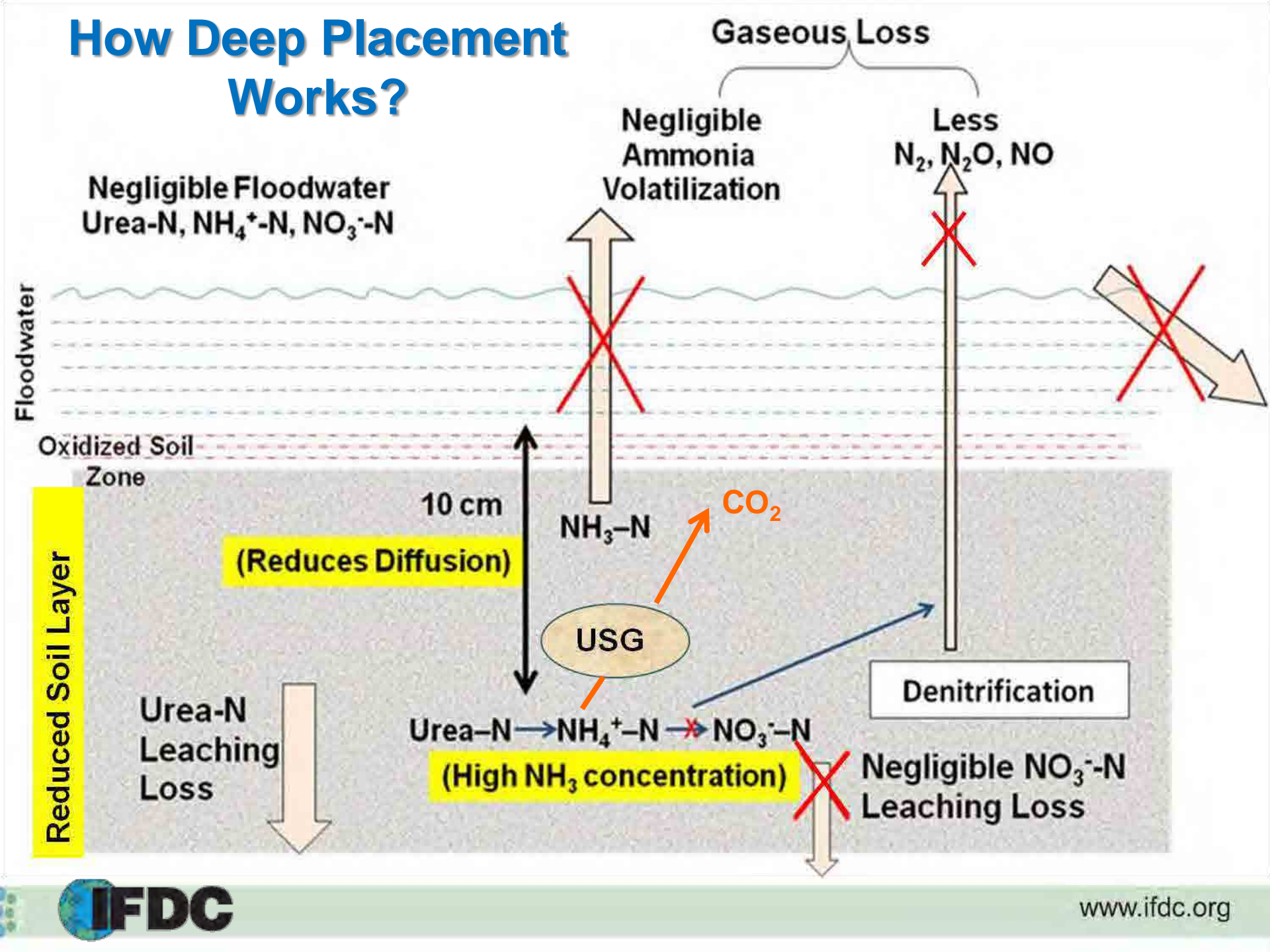
Denitrification

Urea-N  $\rightarrow$   $NH_4^+$ -N  $\rightarrow$   $NO_3^-$ -N  
(High  $NH_3$  concentration)

Negligible  $NO_3^-$ -N Leaching Loss

Urea-N Leaching Loss

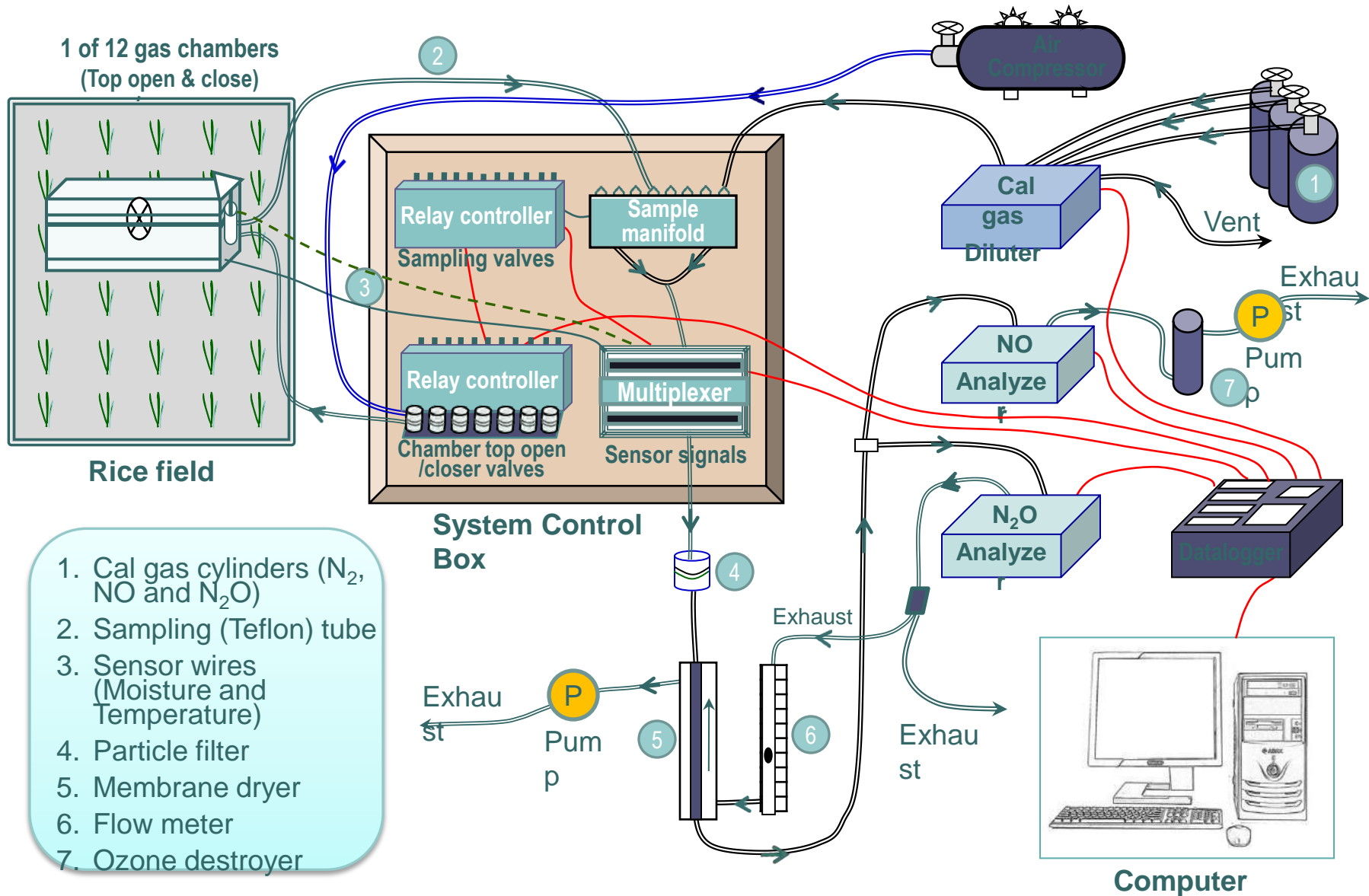
Reduced Soil Layer



# Methodology

- ❖ **Automated continuous measurement**
  - **N<sub>2</sub>O (Gas Filter Correlation N<sub>2</sub>O analyzer, Model T320U, Teledyne API)**
  - **NO (Chemiluminescence NO-NO<sub>x</sub> Analyzer, Model T200, Teledyne API)**
- ❖ **Data recorded using CR3000 (Campbell Scientific)**
- ❖ **Each chamber (57.1 liter) is sampled 8 times a day (3 hour interval)**
- ❖ **Chamber remains closed only for 40 minutes during each sampling time**





**Schematic diagram of automated gas (N<sub>2</sub>O and NO) sampling and analysis system**



**USAID** **IFDC**

Integrating Green House Gas Emissions Mitigation into the Feed the Future Bangladesh Fertilizer Deep Placement Rice Intensification Project

**B. Continuous Standing Water (CSW) Condition**

Treatment	Description
T <sub>1</sub>	Check (NoPaK)
T <sub>2</sub>	UDP (NoPaK)
T <sub>3</sub>	UDP (NoPaK)
T <sub>4</sub>	PU (NoPaK)
T <sub>5</sub>	UDP (NoPaK)
T <sub>6</sub>	NPK Ingotable (NoPaK)
T <sub>7</sub>	PU (NoPaK)
T <sub>8</sub>	NPK Ingotable (NoPaK)

Replication: 3  
 Plot Size: 4.8m x 2.2m  
 Variety: BRRI dhan28  
 Date of transplanting: 11 January 2014  
 Location: BRRI, Gazipur  
 Investigator: Dr. Prasenjit Kumar Saha and S.M. Rafiqul Islam

R<sub>1</sub>T<sub>2</sub>  
UDP-N<sub>75</sub>

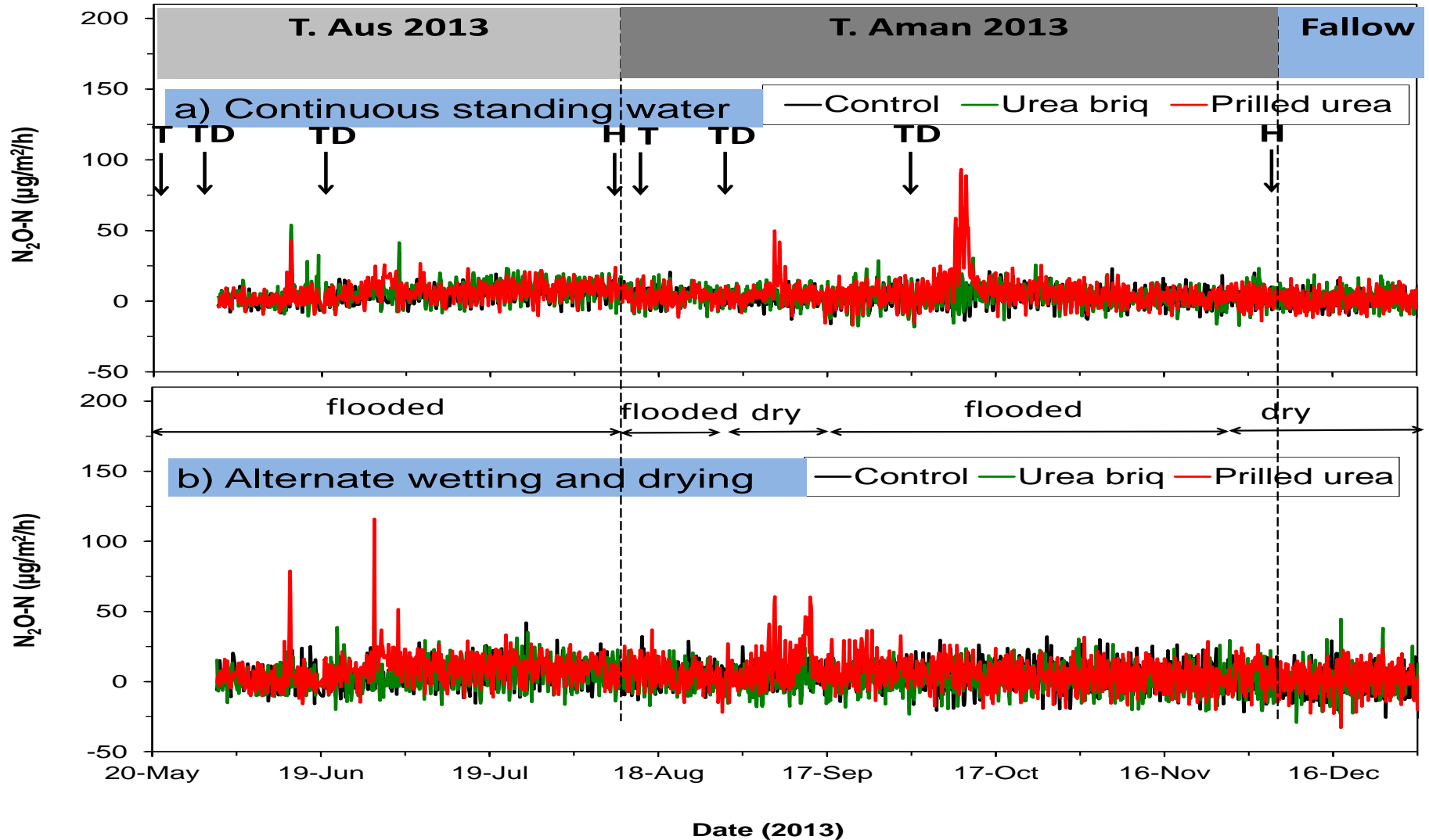
R<sub>1</sub>T<sub>1</sub>  
Control

CHAMBER 1

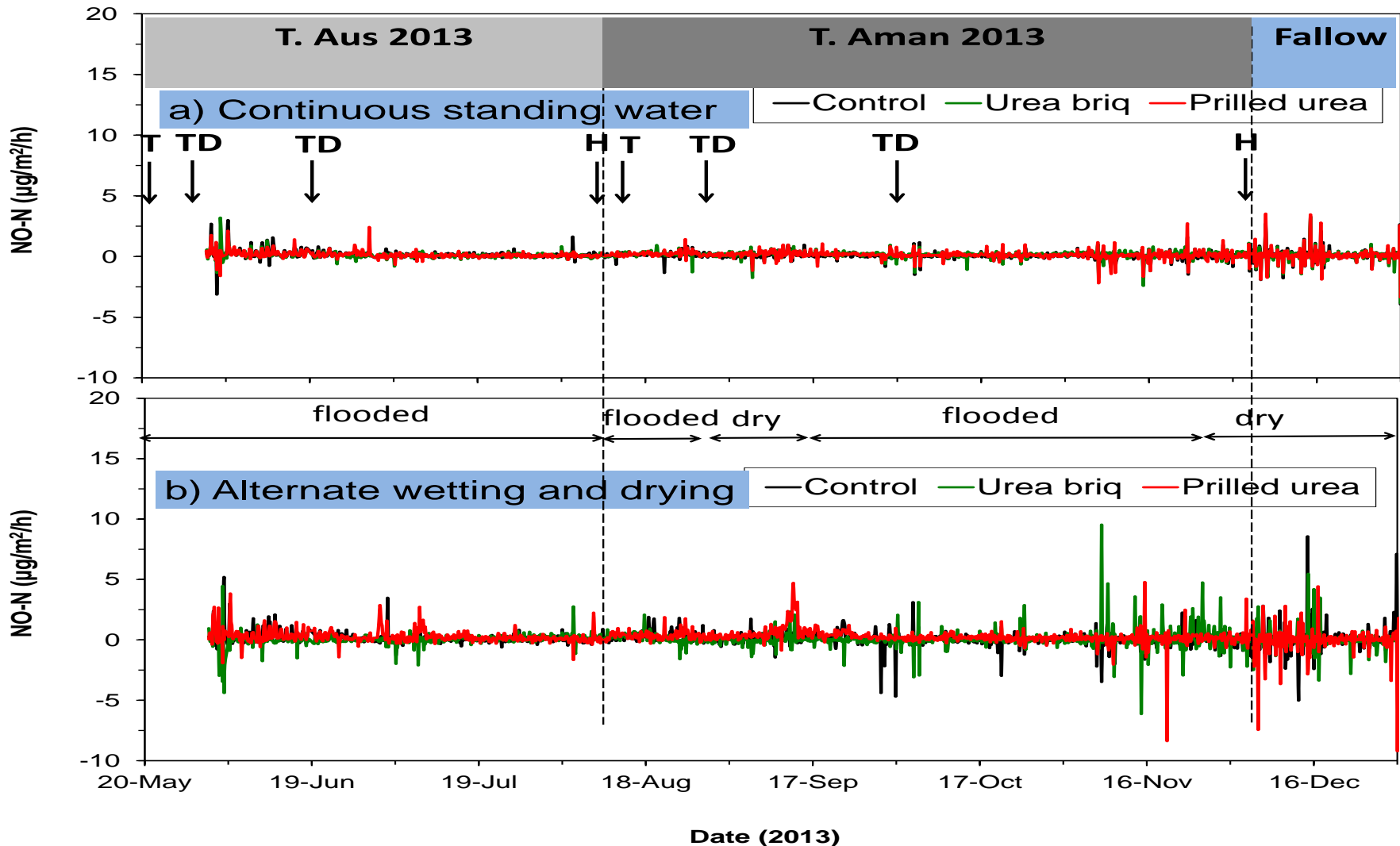


- ❖ Two locations in Bangladesh
  - Bangladesh Agricultural University (BAU)
  - Bangladesh Rice Research Institute (BRRI)
  
- ❖ Growing season
  - T-Aus (Wet season, June-August)
  - T-Aman (Wet season, August-Nov)
  - Boro (dry season, Jan-April)

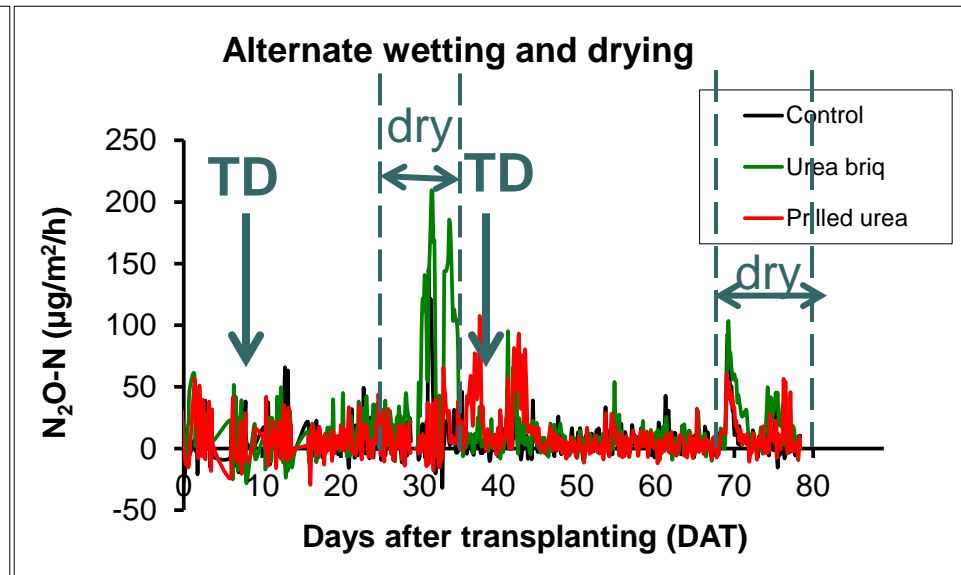
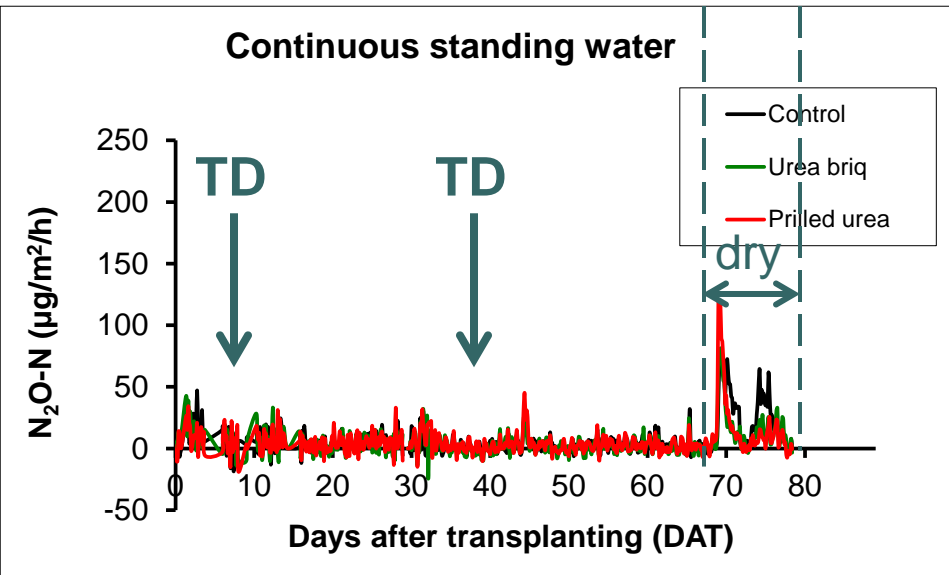
# N<sub>2</sub>O emissions at BAU



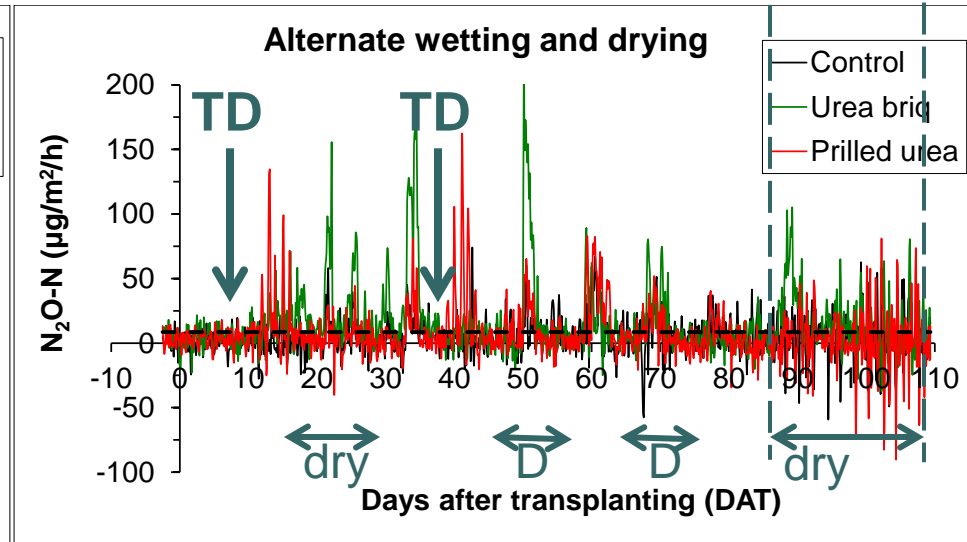
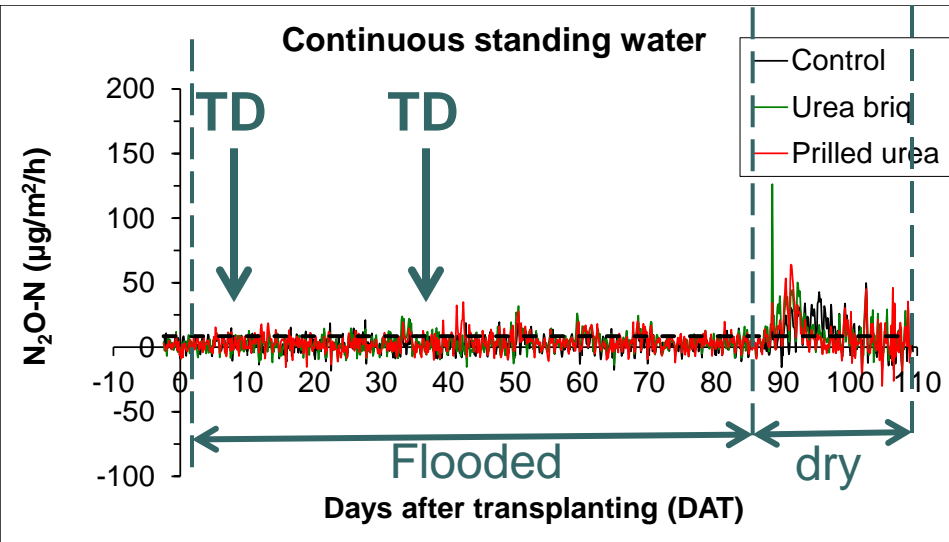
# NO emissions at BAU



# N<sub>2</sub>O: Aus 2013

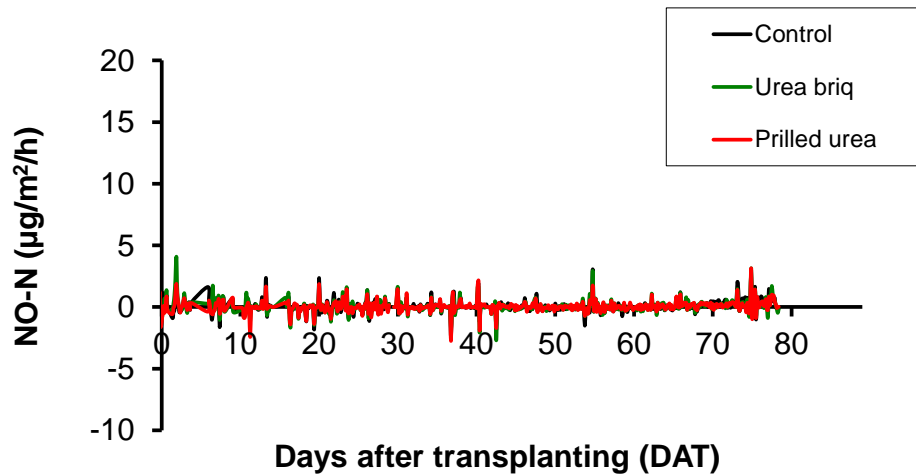


# N<sub>2</sub>O: Aman 2013

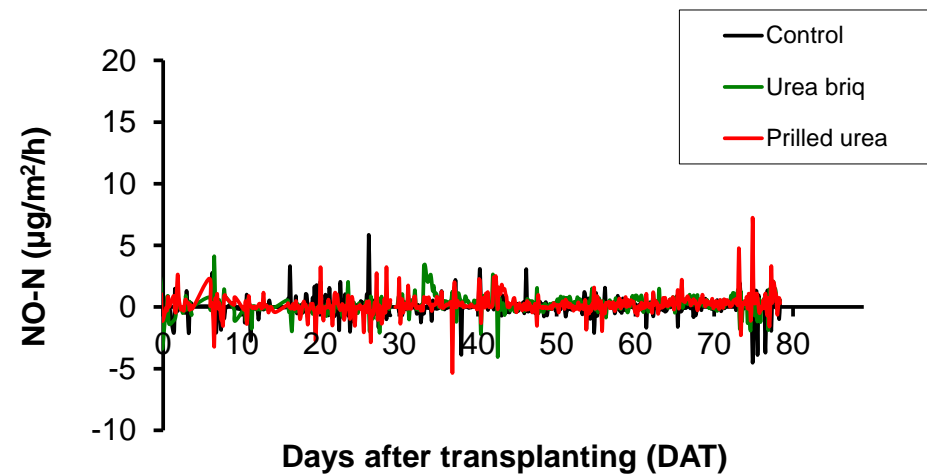


# NO: Aus 2013

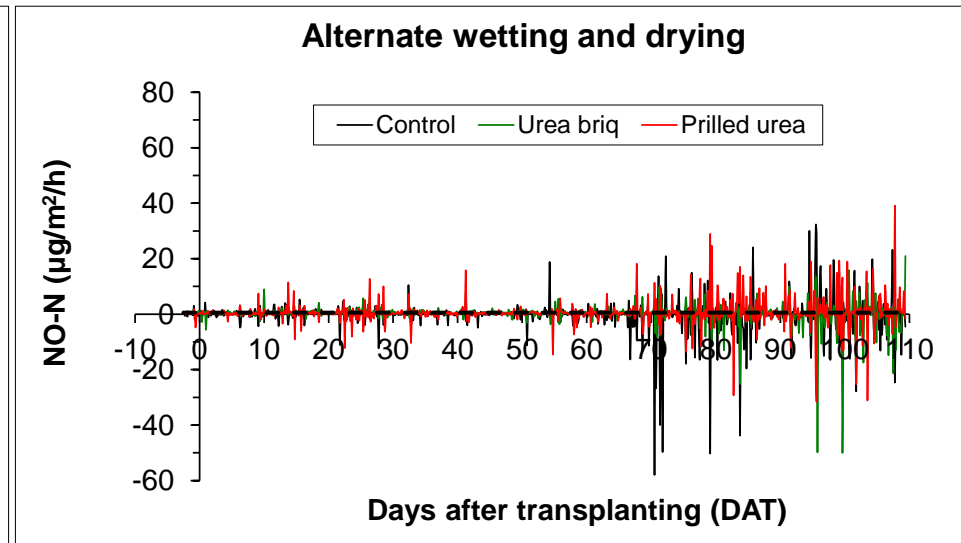
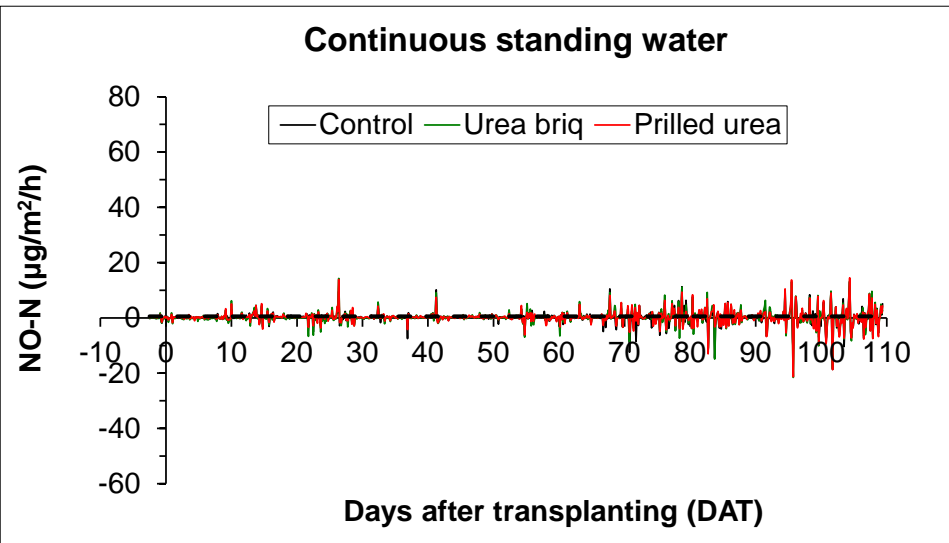
## Continuous standing water



## Alternate wetting and drying



# NO: Aman 2013

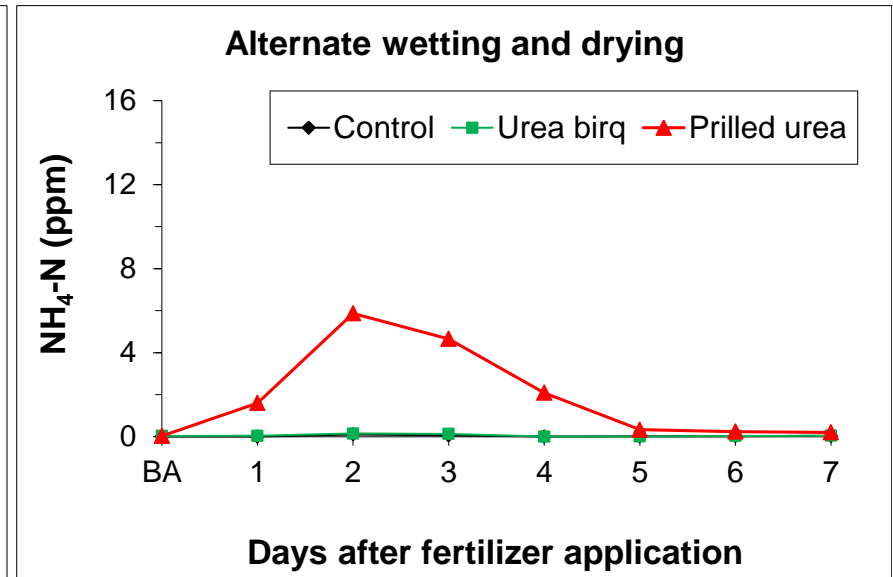
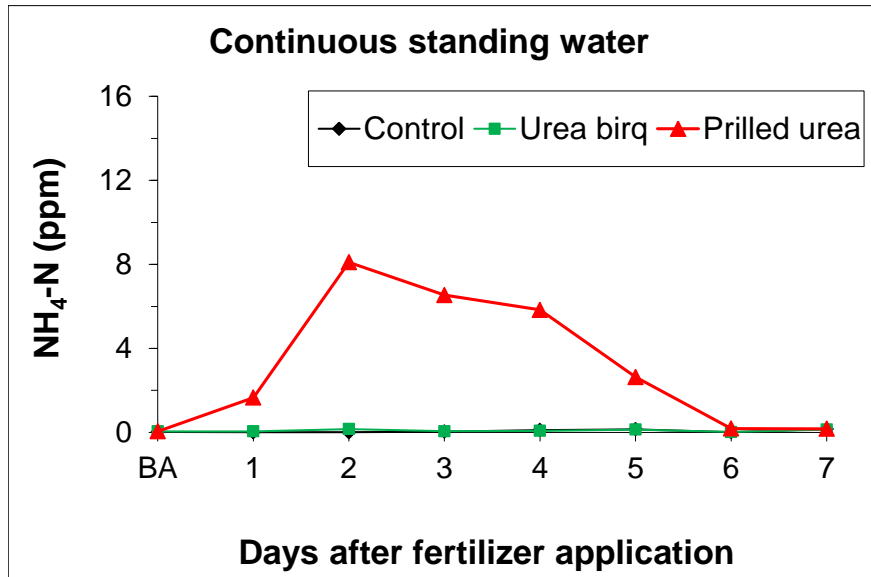


# Conclusions

- ❖ N<sub>2</sub>O and NO emissions are negligible under CSW, while significant emissions occurred under AWD.
- ❖ However, emissions peaks appeared after broadcast application of urea but not from deep placement.
- ❖ Deep placement increased emissions under AWD.
- ❖ Ongoing *Boro (Dry season)* trials will provide crucial information on effect of AWD and N management on emissions.



# Ammonium-N in floodwater





# Experimental databases and model of N<sub>2</sub>O emissions by croplands

Do we have what is needed to explore  
mitigation options?

Concluding remarks



## **N<sub>2</sub>O emissions by agricultural soils**

- Complex, not fully elucidated underlying processes
- Very small fluxes, highly variables in space and time
- Numerous shortcomings about measurement techniques
- Remaining knowledge gaps (e.g. N<sub>2</sub>O consumption, multiple processes...)
- Progresses are expected from new tools (isotopes, molecular biology,...)
- Better understanding of underlying processes will probably help to improve models so that they better account for the effect of management practices, but it remains debatable



## Effect of agricultural practices on N<sub>2</sub>O emissions and levers for mitigation

- This question has received attention from agronomists only recently
- The metrics which is used to compare agricultural practices is a key issue (area-scaled N<sub>2</sub>O? Yield-scale N<sub>2</sub>O?,...)
- Important to have complete N budget data and other GHG. Important to consider (multi)year round measurements
- Some levers for mitigation have been clearly identified (reduce N excess, legumes, cover crops,...).
- Need for synthetic papers, for the most widely studied practices (e.g. N fertilisation)
- Some techniques, which may offer levers for mitigation in the mid-term, need further studies (e.g. fertiliser placement, biochars, liming, ...)
- The biodegradation of organic products (crop residues, manure) and associated N<sub>2</sub>O emissions must be better understood
- The effect of highly disturbing management practices (land use change) or events (freeze-thaw) must be quantified
- We need more studies in dryland contexts
- There is a strong need to design and assess cropping systems with a multicriteria approach (not only GHG but also crop production, reduced use of pesticides,...)



# Models

- Models are definitely an appropriate tool
  - to decipher the relative effects of soil properties, climate, agricultural management practices;
  - to interpret and compare data from different experiments;
  - to make prediction
- They don't work so bad
- Process based model (e.g. DNDC, Daycent, Stics,...) successfully simulate the effect of several key agricultural practices, although not always the accurate temporal dynamic. Clarify how they do the job ?
- We should not fear model failure
- Could we still improve synergy between data collection and modelling efforts in a win-win process
  - For experimentalists: Better interpretation of their results
  - For modellers: Model evaluation in a wider range of contexts
  - But intermediate variables should be measured (e.g.  $\text{NO}_3^-$ ,  $\text{NO}_2^-$ , WFPS) and how model account for the effect of management practices must be made more transparent
- Models don't simulate long term, cumulative effects of cropping systems on important variables (pH, soil porosity,...)
- Upscaling at large scale (which is the relevant scale for policy making) is an important objective



## What will happen now?

- Workshop 2 will start just after. The key word is model intercomparison.
- Ppt presentation will be available on the GRA website (if authors agree for that)



## Thanks to

The key-note speakers and authors of oral presentations and posters  
for their contributions

Chairs and co-chairs

Members of the scientific and organisation committee

INRA and Ademe for financial support

Fiona and Lénaïc for practical organisation

All of you for active participation in discussions