Nitrogen mineralization and greenhouse gas emissions after soil incorporation of ensiled and composted grass-clover as green manure

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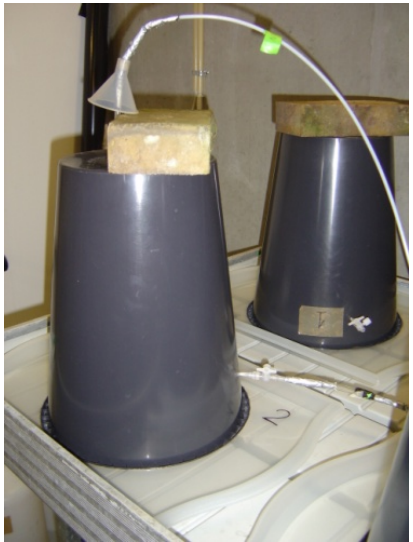
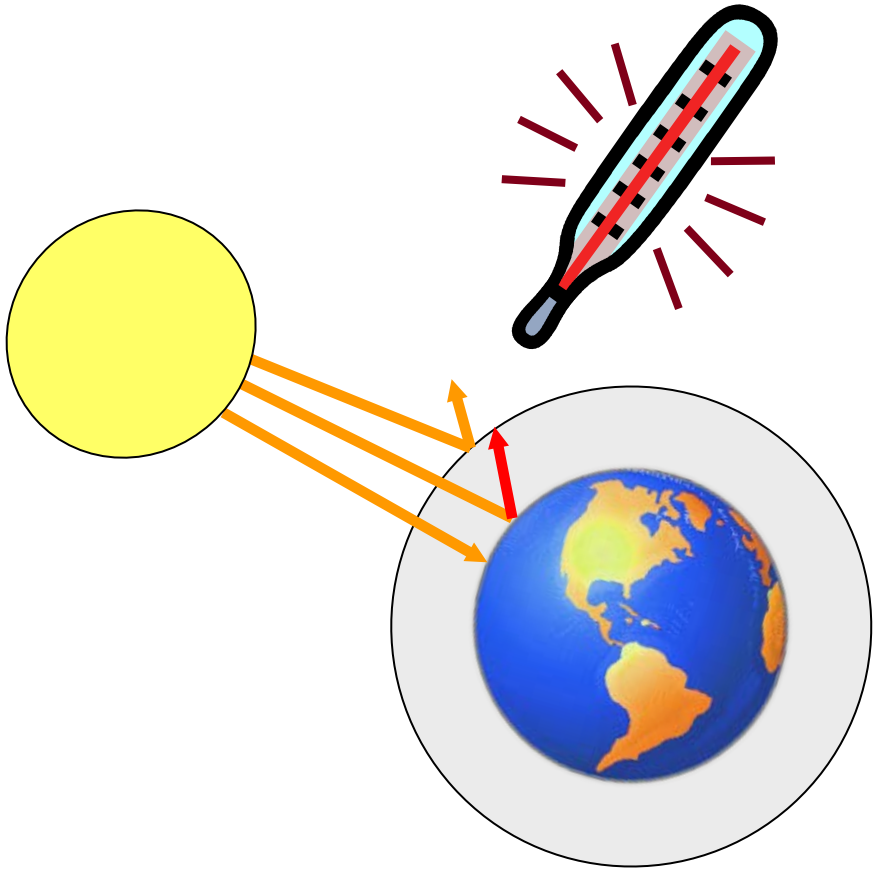


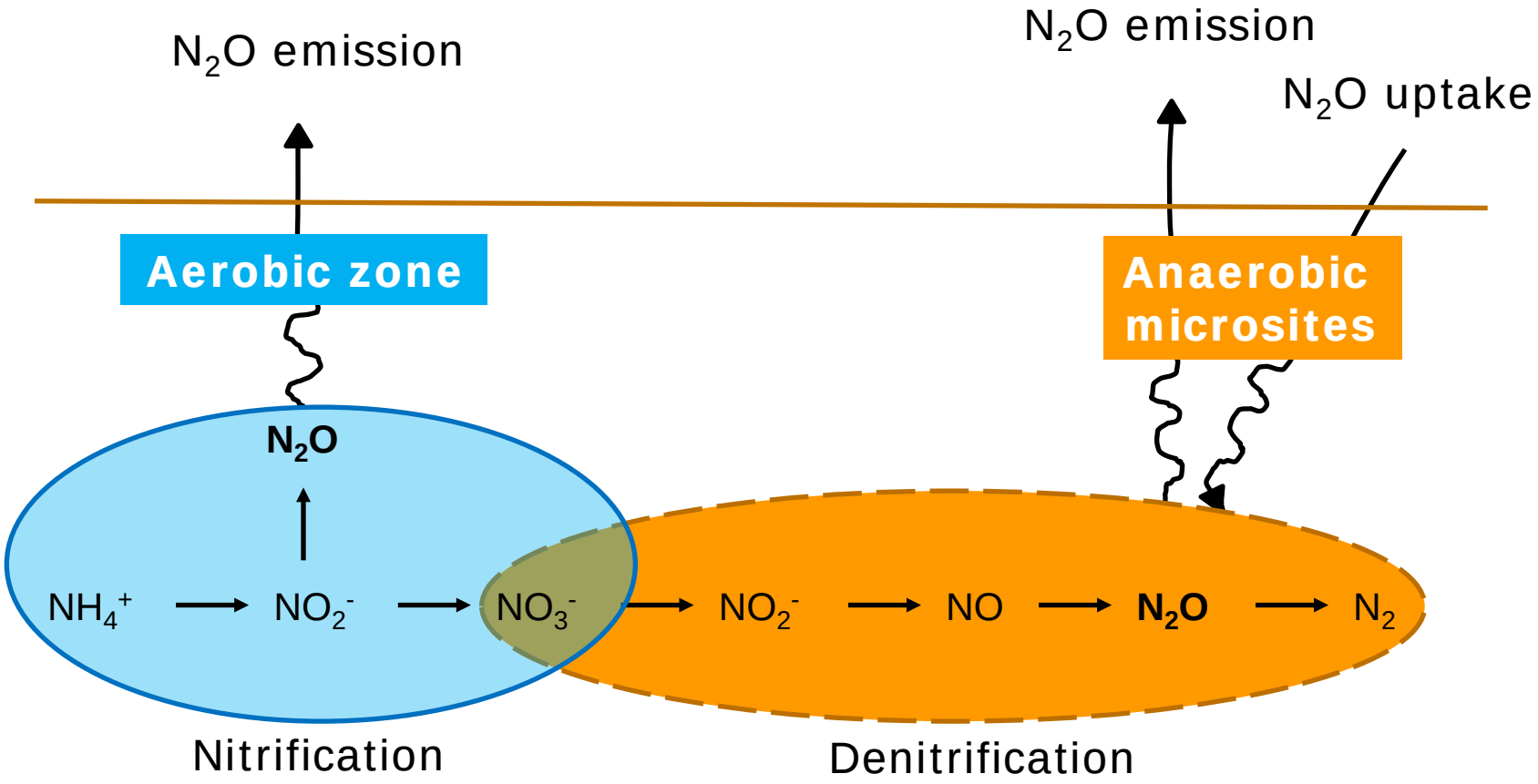
N_2O is a greenhouse gas



The global warming potential of 1 kg N_2O corresponds to 298 kg CO_2

IPCC, 2007

Microbial soil processes producing N_2O



Based on Baggs, 2011

N input in stockless organic arable farming

Example of crop rotation

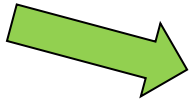
2011 Spring barley
2012 Grass-clover (green manure)
2013 Potato
2014 Winter wheat
2015 …

Typical management of green manure leys

- Grass-clover leys are cut 2-5 times during the growing season
- Cuttings are left as mulch on the soil surface
- The sward is ploughed in before the following crop is established

N input in stockless organic arable farming

	Field 1
2011	Spring barley
2012	Grass-clover (green manure)
2013	Potato
2014	Winter wheat
2015	…



Field 2

Potato

Winter wheat

Spring barley

Grass-clover

Risk when mulching green manure leys:

- Gaseous N losses (NH_3, N_2O and N_2)
- Nitrate leaching

New strategy for green manure leys:

1. Grass-clover cuttings are harvested
2. Stored as compost or silage
3. Applied to a spring sown crop

Grass-clover green manures used in the experiment

	Compost	Silage	Mineral
Dry matter (%)	75	46	
C:N ratio	15.8	15.0	
Application rate (kg N ha^{-1})	120	120	80

Purpose of experiment

1. Compare composted and ensiled grass-clover green manure concerning their abilities to provide plant-available N during a 3-month period

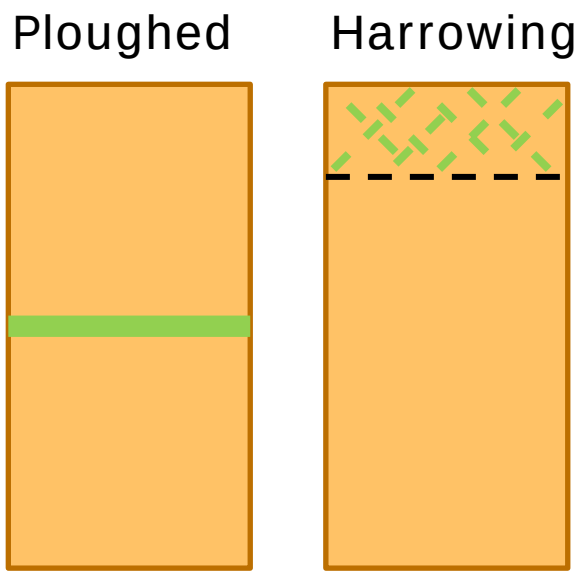
   Hypothesis: Fastest net N release from silage

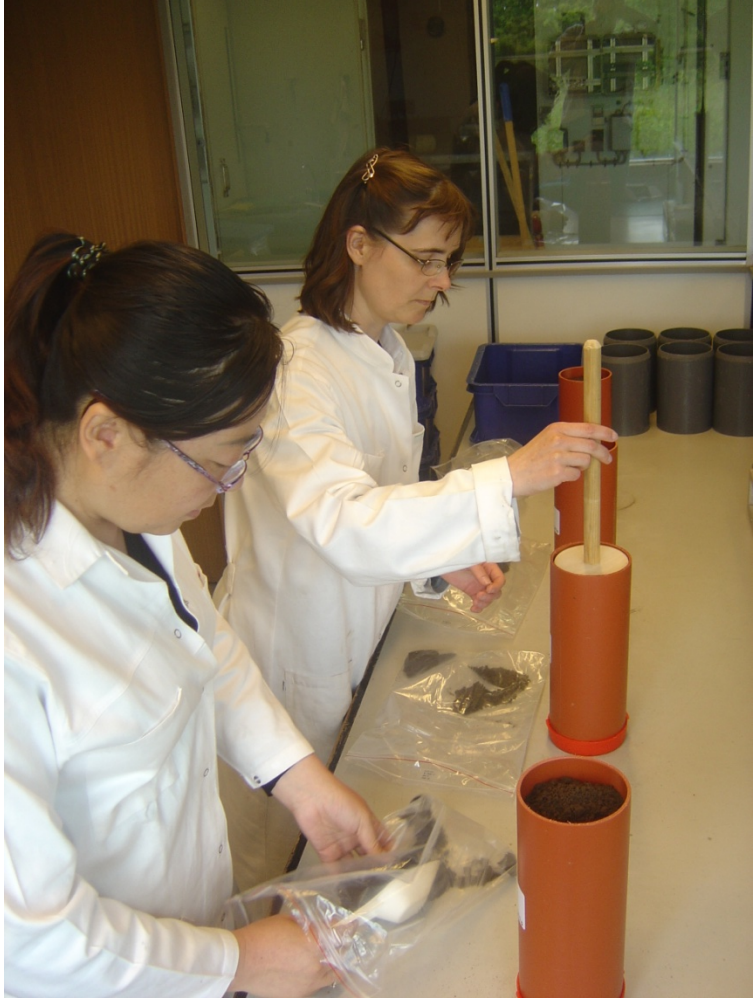
2. Assess how storage methods (compost vs. silage) affect N_2O fluxes and soil respiratory CO_2 emissions after soil application of the green manures

3. Does it make any difference to the greenhouse gas fluxes whether the green manures are incorporated by harrowing or ploughing?

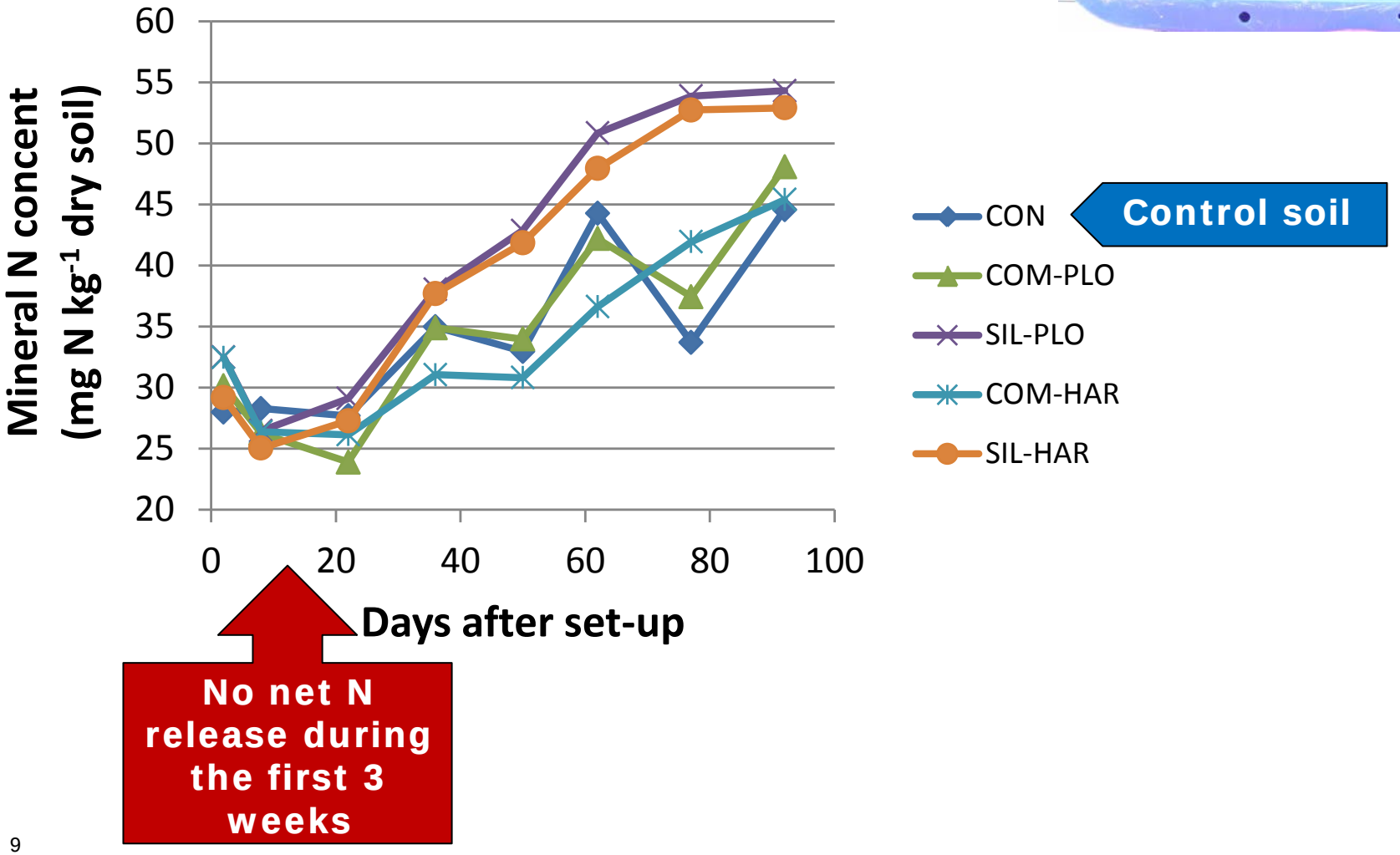
Treatments

CON	Control
MIN	Mineral fertilizer $(NH_4)_2SO_4$
COM-PLO	Compost Ploughed (15 cm)
SIL-PLO	Silage Ploughed (15 cm)
COM-HAR	Compost Harrowing (0-5 cm)
SIL-HAR	Silage Harrowing (0-5 cm)

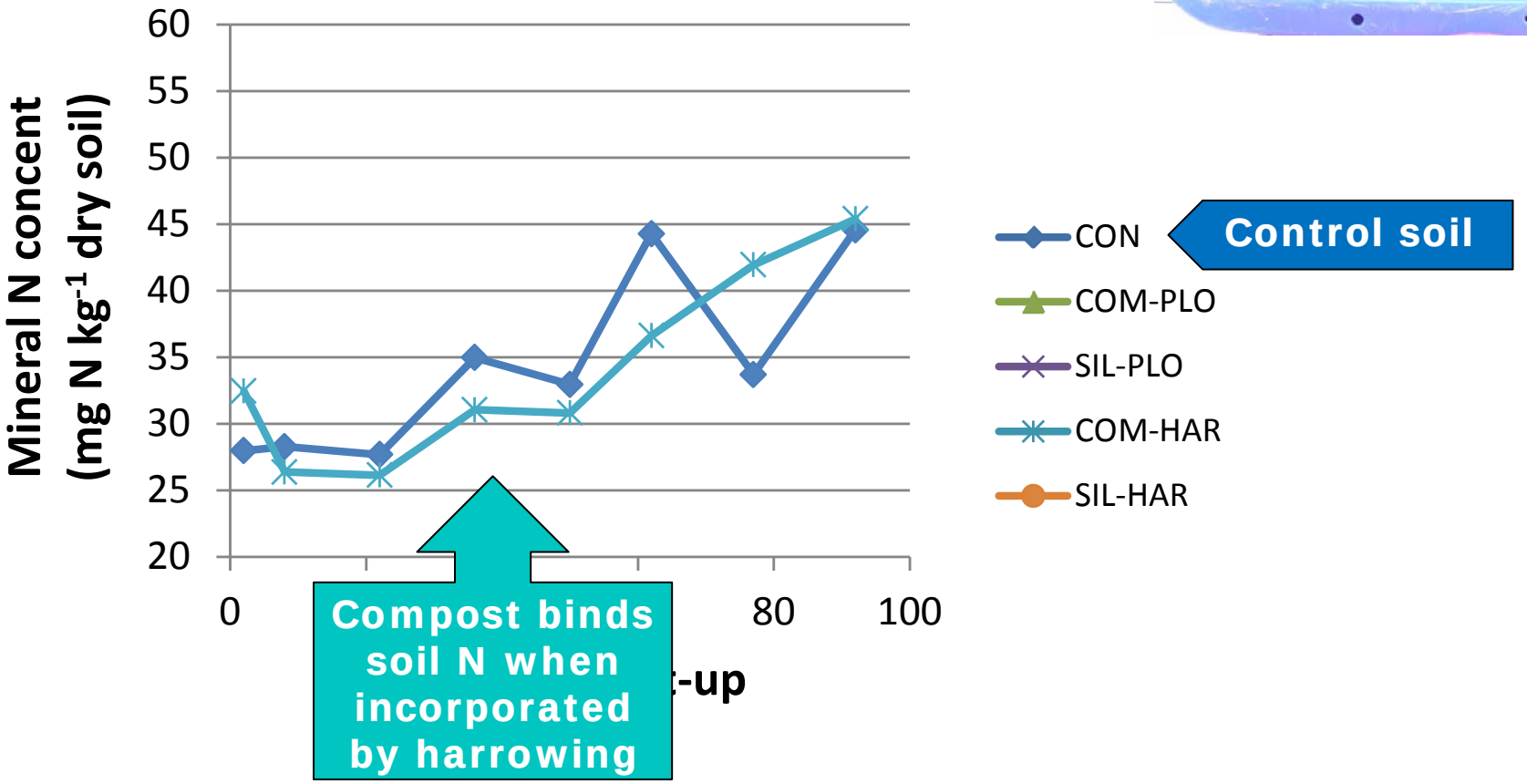




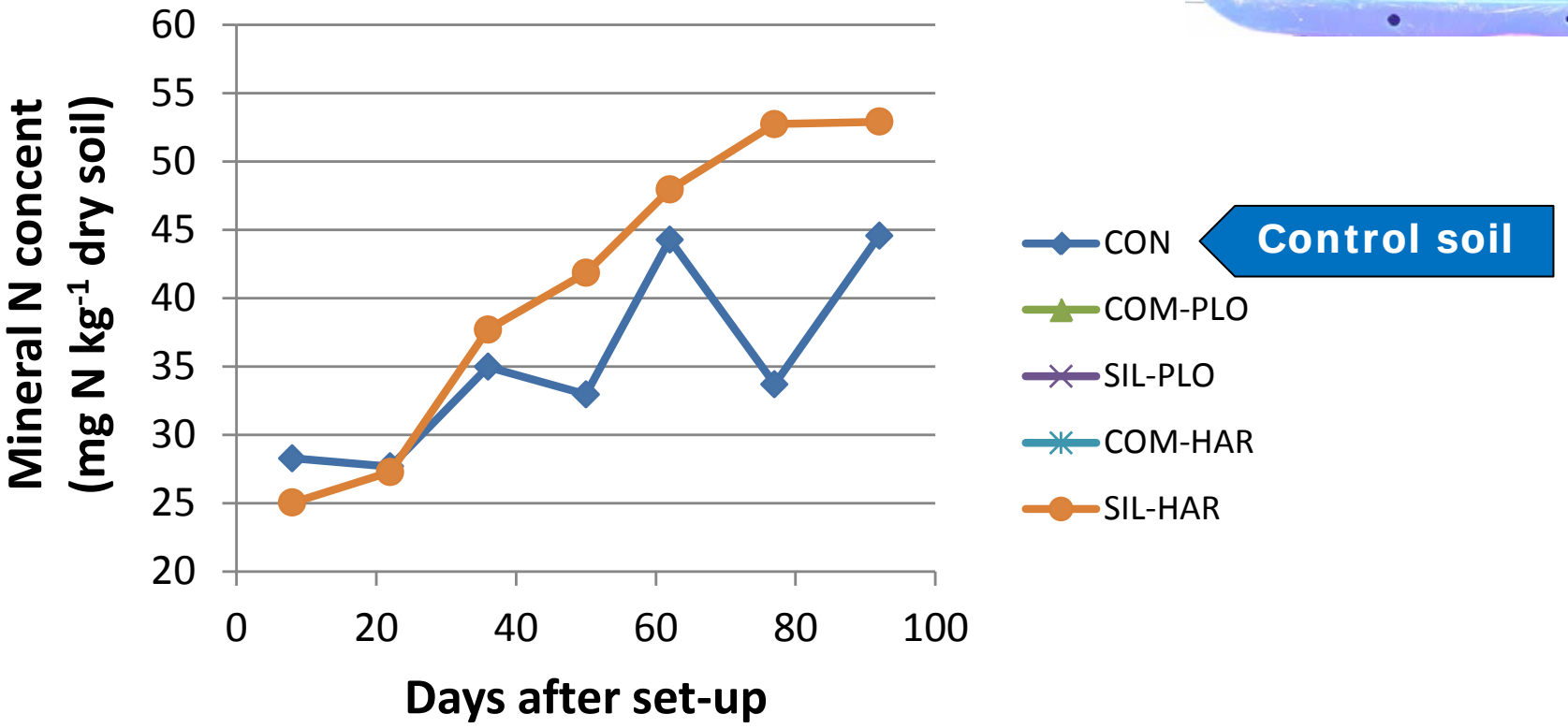
Soil mineral N during 92 days



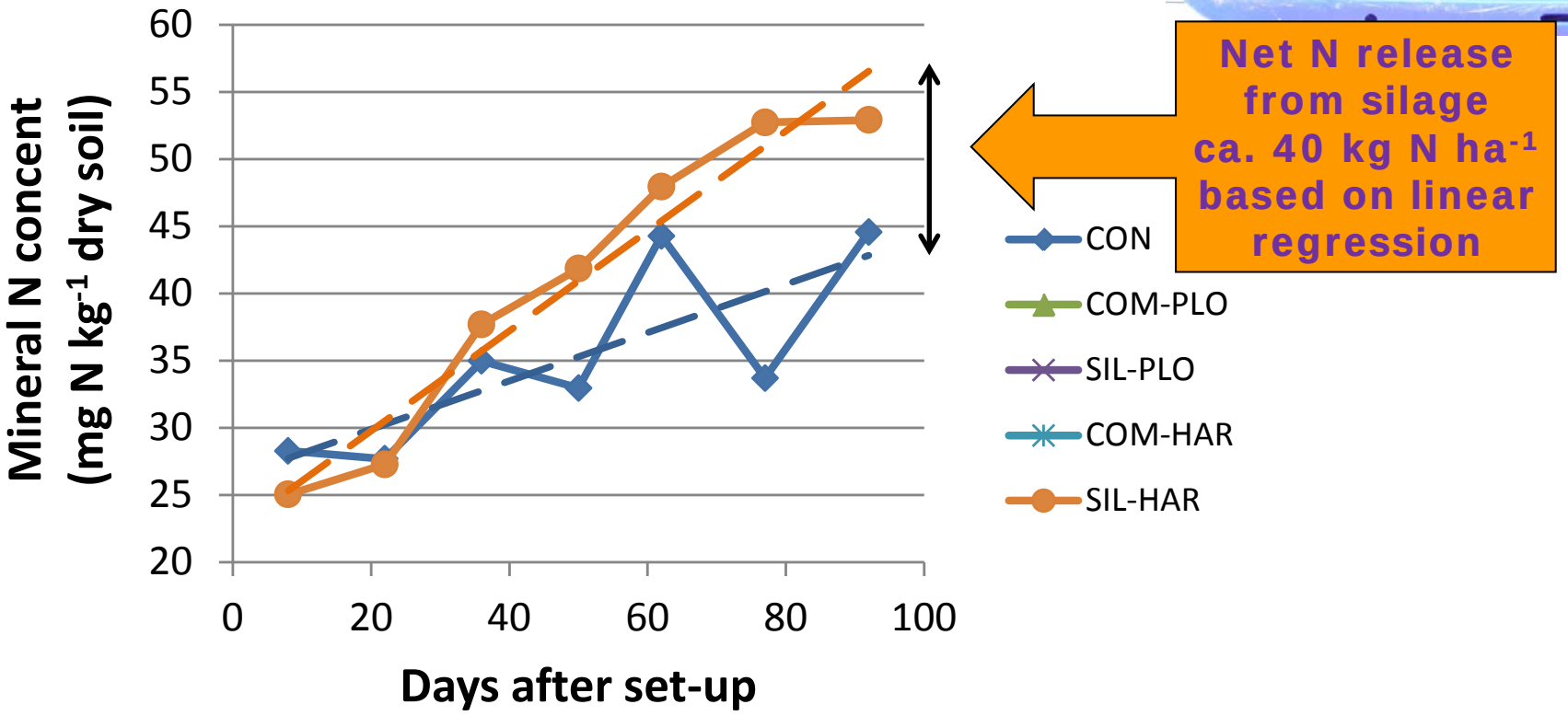
Comparison of control and Compost Harrowing (COM-HAR)



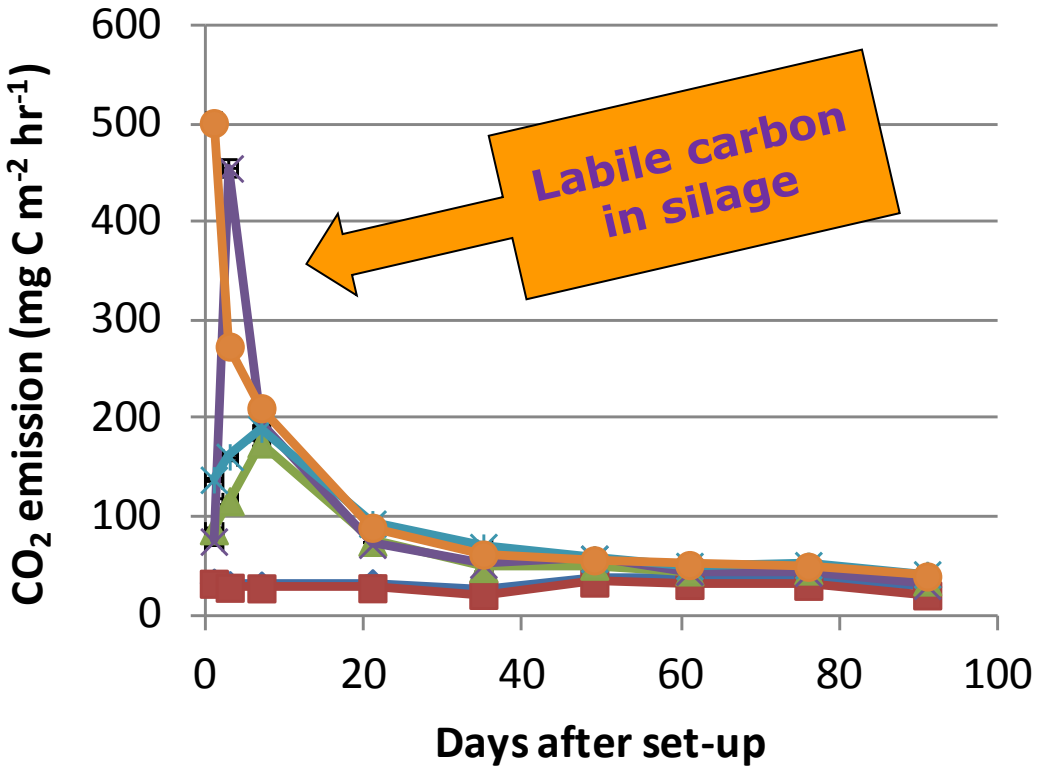
Comparison of control and Silage Harrowing (SIL-HAR)



Comparison of control and Silage Harrowing (SIL-HAR)

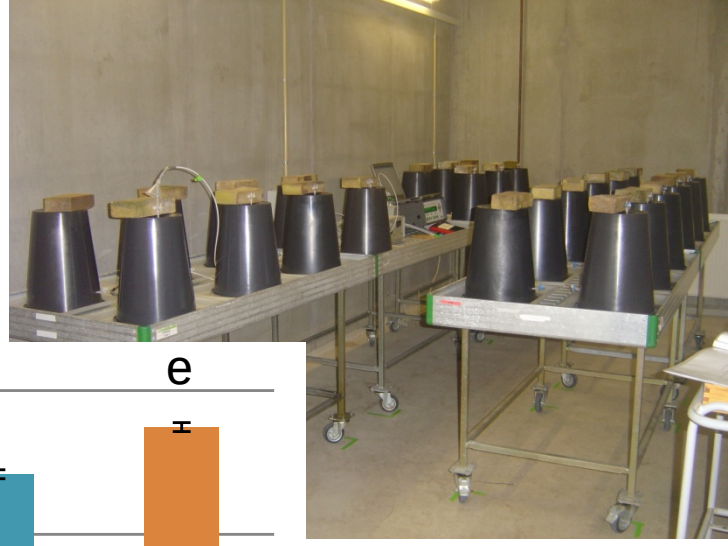


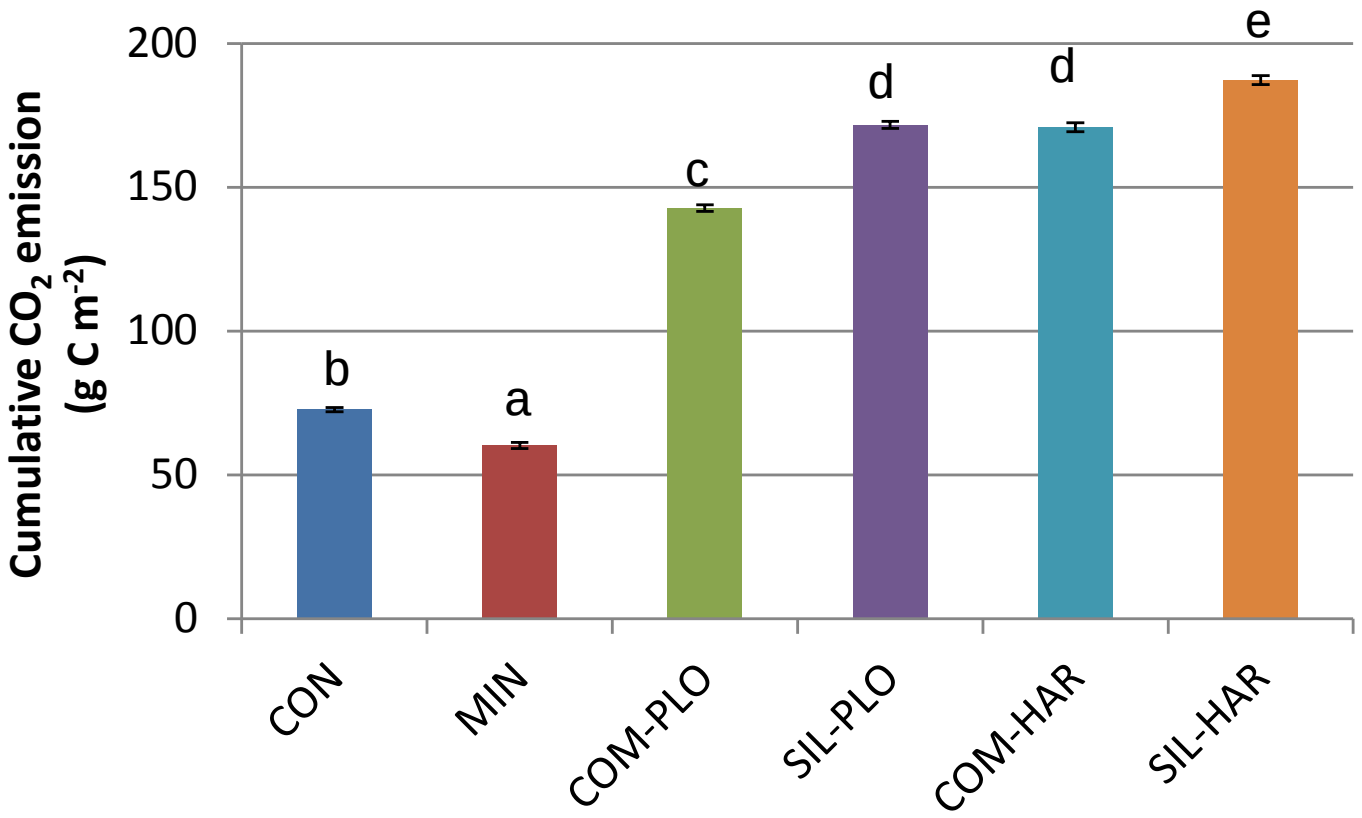
Emission of CO_2



CON
MIN
COM-PLO
SIL-PLO
COM-HAR
SIL-HAR

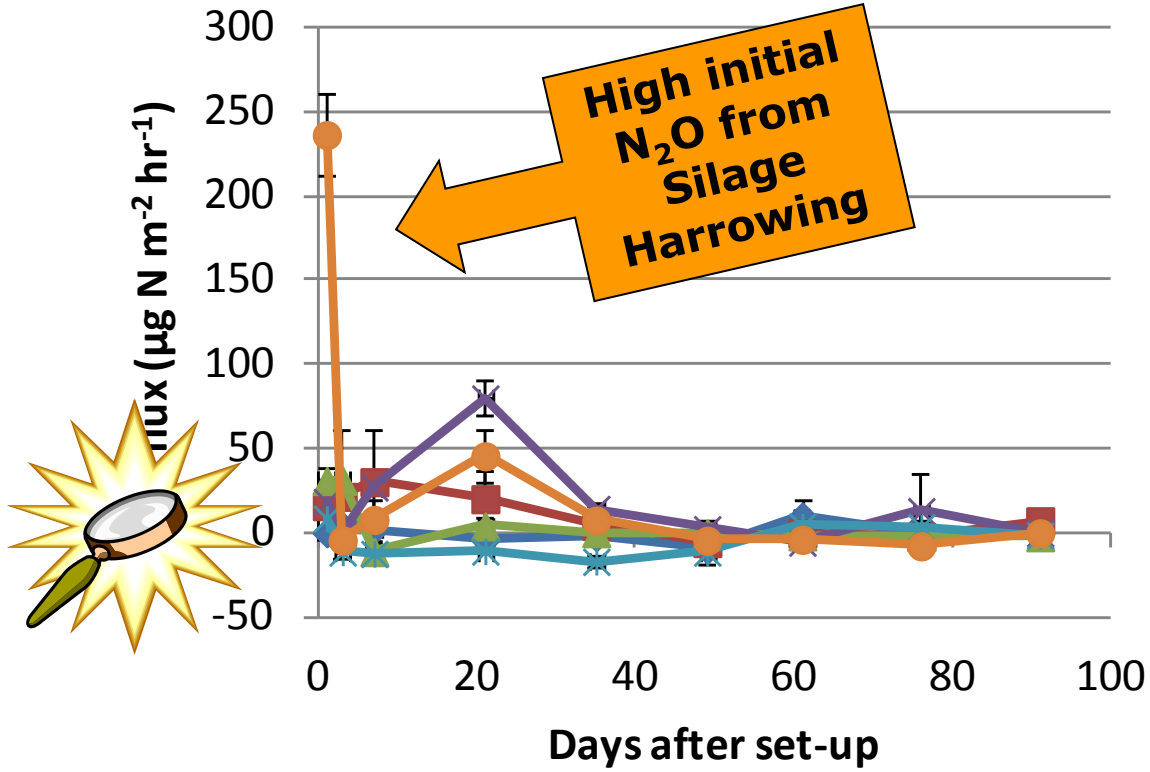
Total CO_2 emissions during 3 months



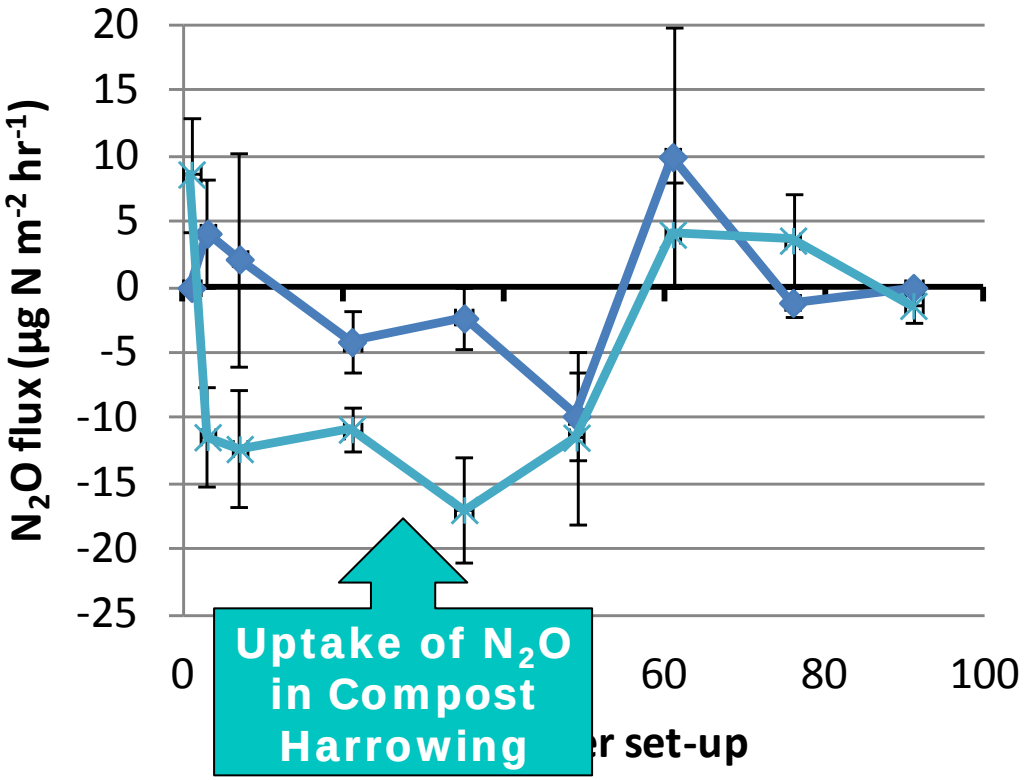


Fraction of green manure carbon respired (%)	37	55	52	63

N_2O fluxes


High initial N_2O from Silage Harrowing
Flux (µg N m^{-2} hr^{-1})
300
250
200
150
100
50
0
-50
0
20
40
60
80
100
Days after set-up
CON
MIN
COM-PLO
SIL-PLO
COM-HAR
SIL-HAR

N_2O fluxes

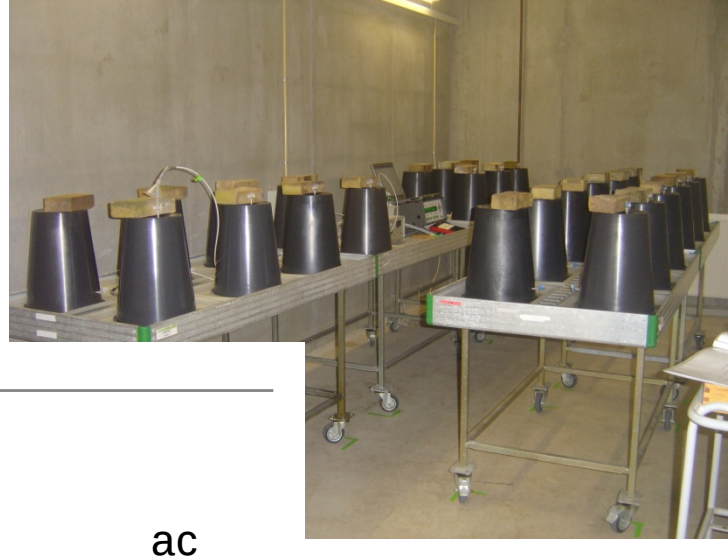


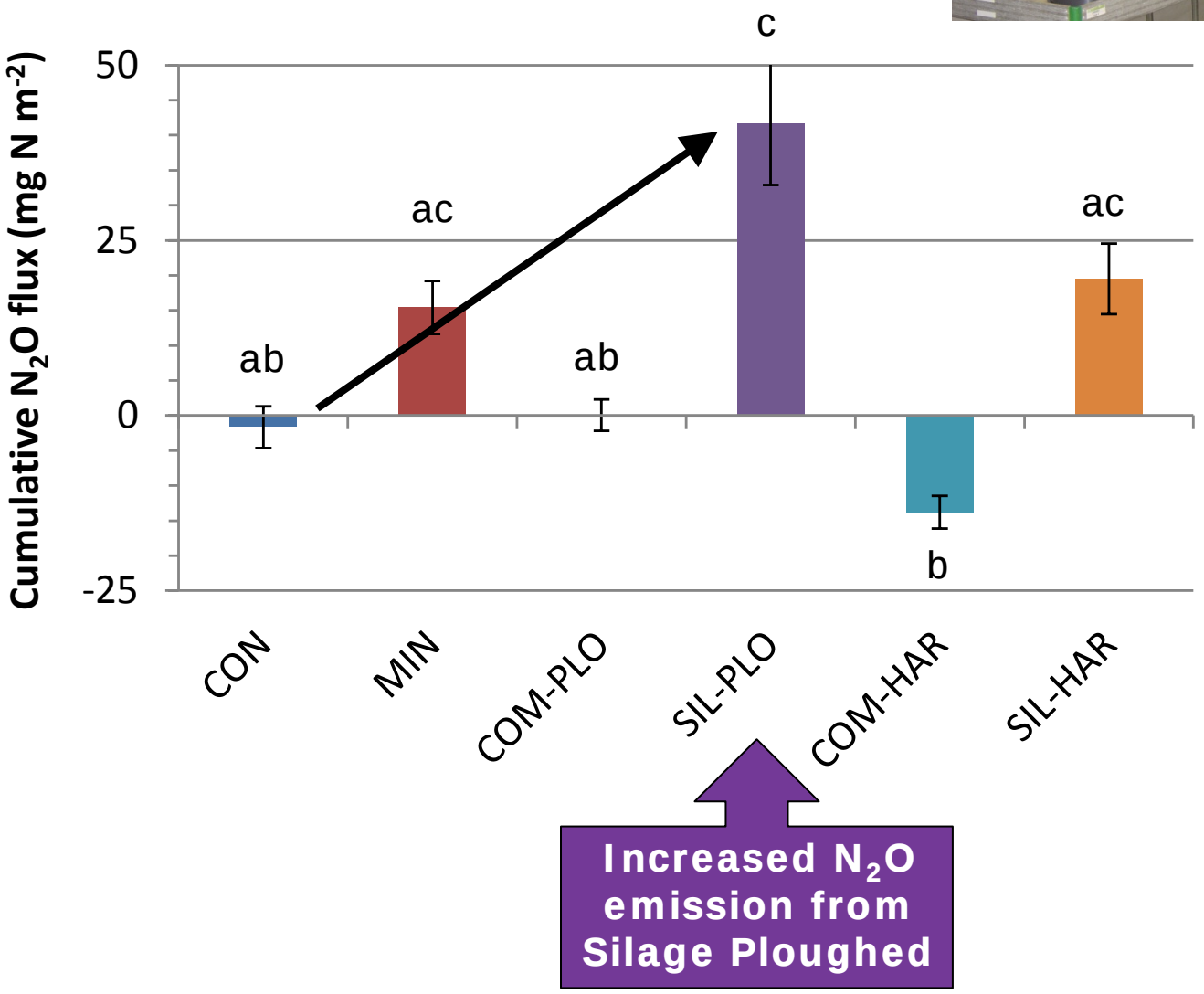
CON

COM-HAR

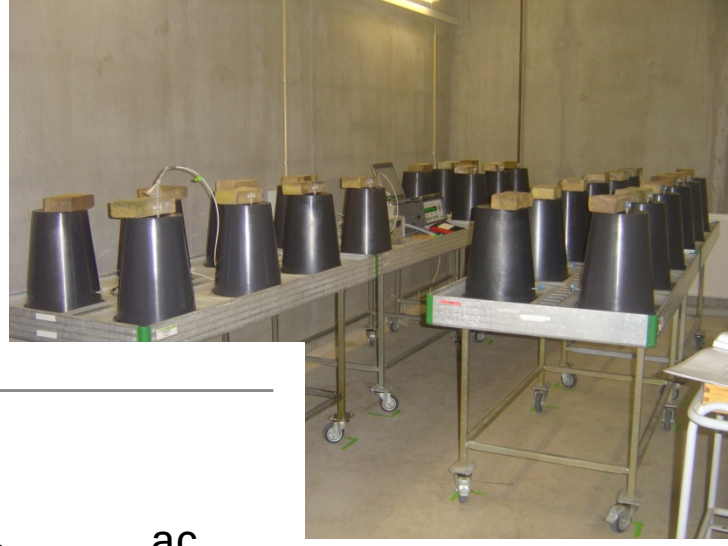
Control soil

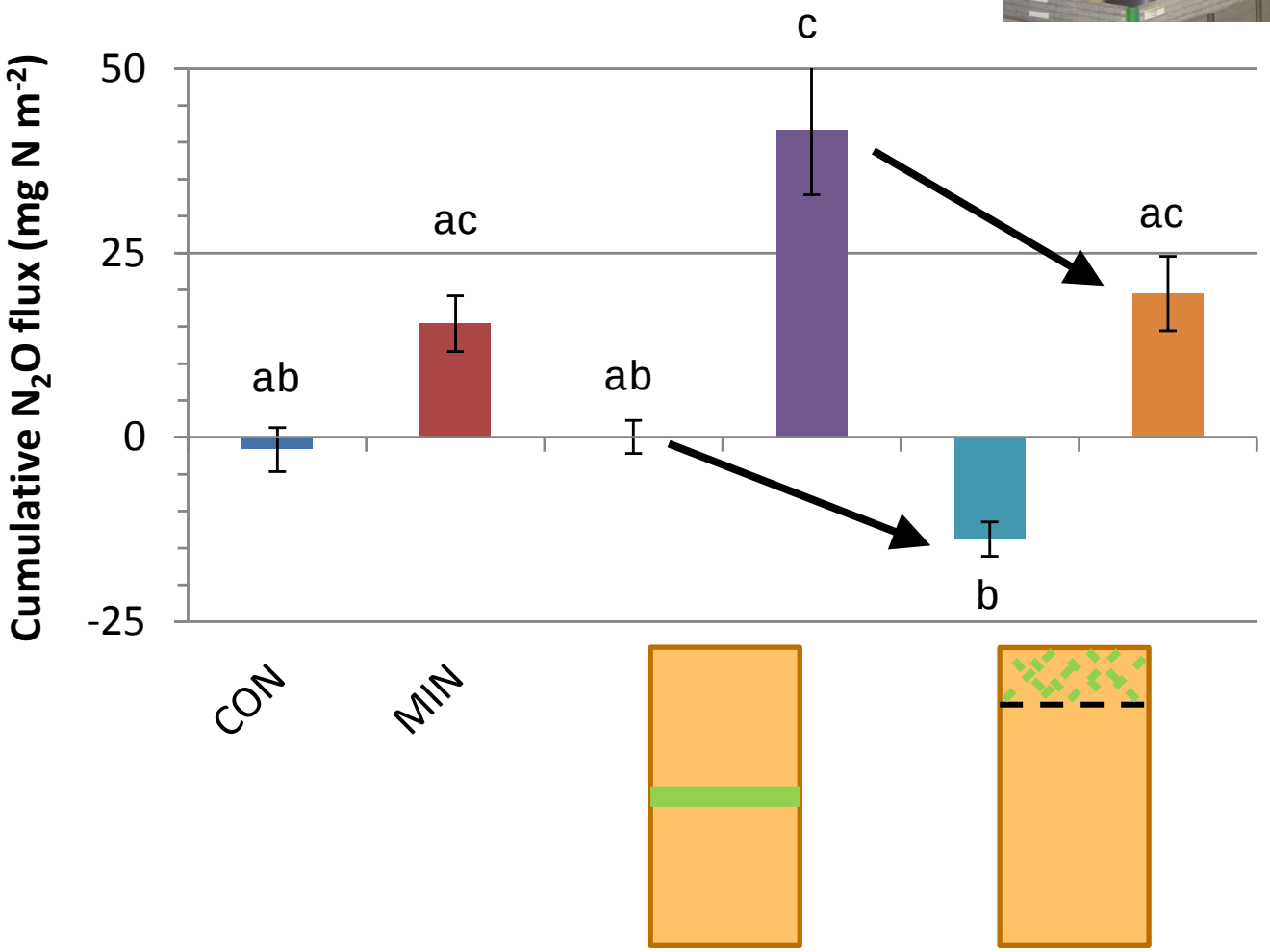
Total N_2O fluxes during 3 months





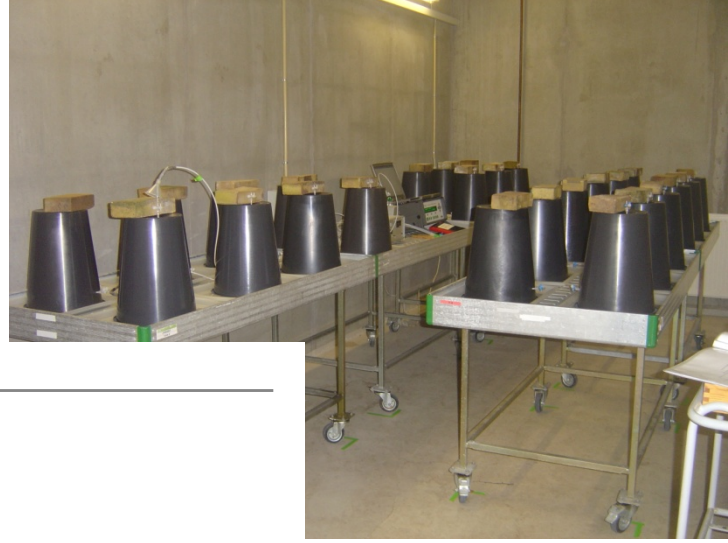
Total N_2O fluxes during 3 months

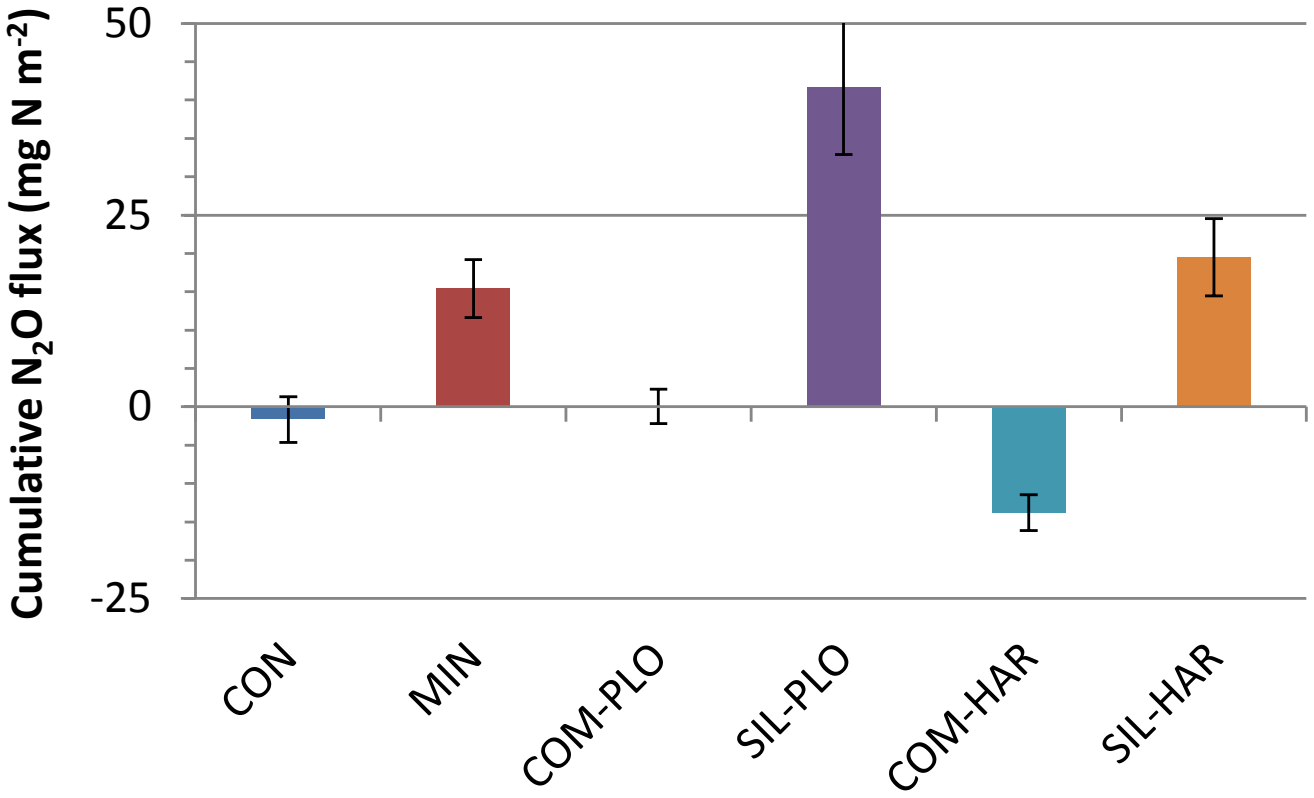




Harrowing instead of ploughing tends to reduce the N_2O efflux

Total N_2O fluxes during 3 months





Fertilizer N emitted as N_2O (%)	0.2	0	0.4	nd	0.2

Main conclusions

1. Fastest net N release from silage, with no difference between the two incorporation methods, ploughing and harrowing (ca. 40 kg N ha^{-1})

2. No measurable net N release from the composted grass-clover and straw mixture during the 3-month experiment
   - **Incorporation of compost by harrowing led to temporal immobilization of soil N**
   - **At the same time, a downwards flux of N_2O was observed, mitigating climate change**

Recommendations

Ensiled grass-clover was the best fertilizer product, and the study indicates that N_2O emissions can be reduced by incorporating green manures by harrowing instead of ploughing

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