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Research Institute of Organic Agriculture
Forschungsinstitut für biologischen Landbau
Institut de recherche de l'agriculture biologique






# How does minimum soil disturbance affect soil quality?

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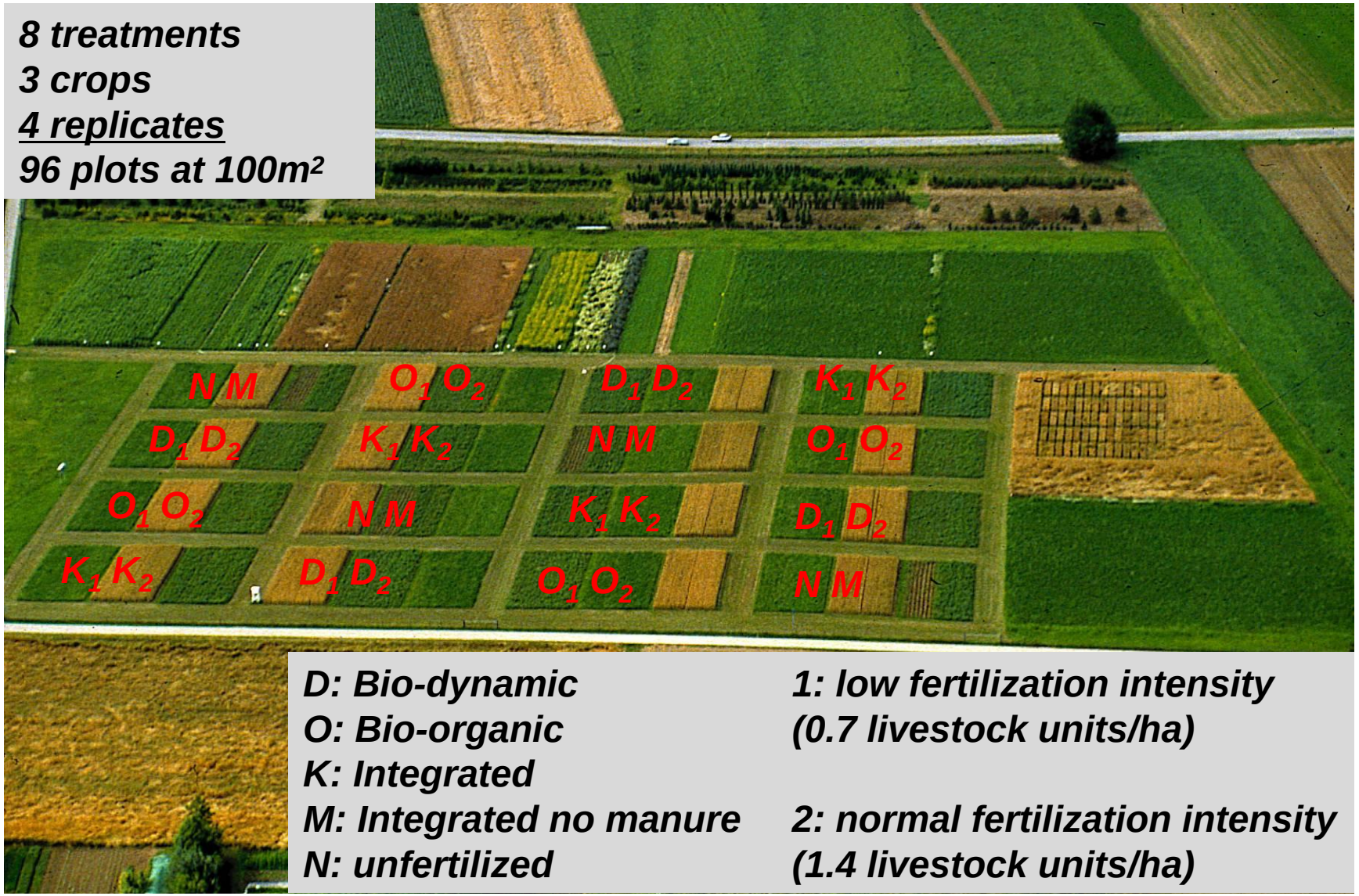
# Challenged agroecosystems

- The adaptation of agriculture to climate change and food security is not sufficient, in particular in Africa and Asia (Lobell *et al*., 2008).
- 60% of the ecosystem functions are degraded due to food production (MEA, 2005).
- Microorganisms govern key soil functions, such as nutrient cycling, decomposition, crop production, soil structure
- Organic farming has proven advantages for soil fertility and biodiversity
- No tillage has positive effects on system performance, but was developed with herbicides and industrial fertilizer
- We were testing soils of the DOK-trial and three organic reduced tillage trials

# The DOK field trial and the farming systems

*8 treatments*
*3 crops*
*<u>4 replicates</u>*
*96 plots at 100m²*

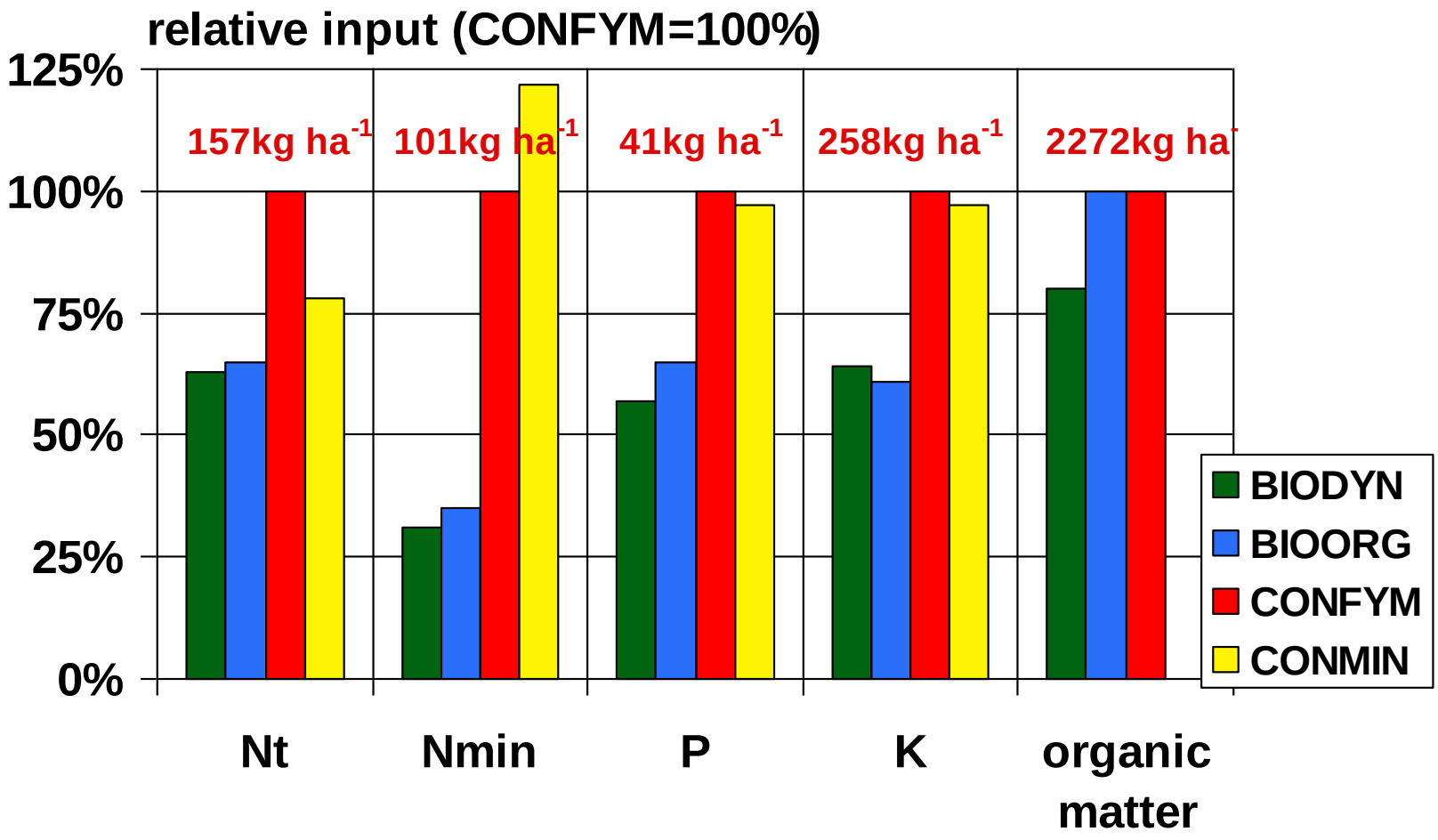



*D: Bio-dynamic*
*O: Bio-organic*
*K: Integrated*
*M: Integrated no manure*
*N: unfertilized*

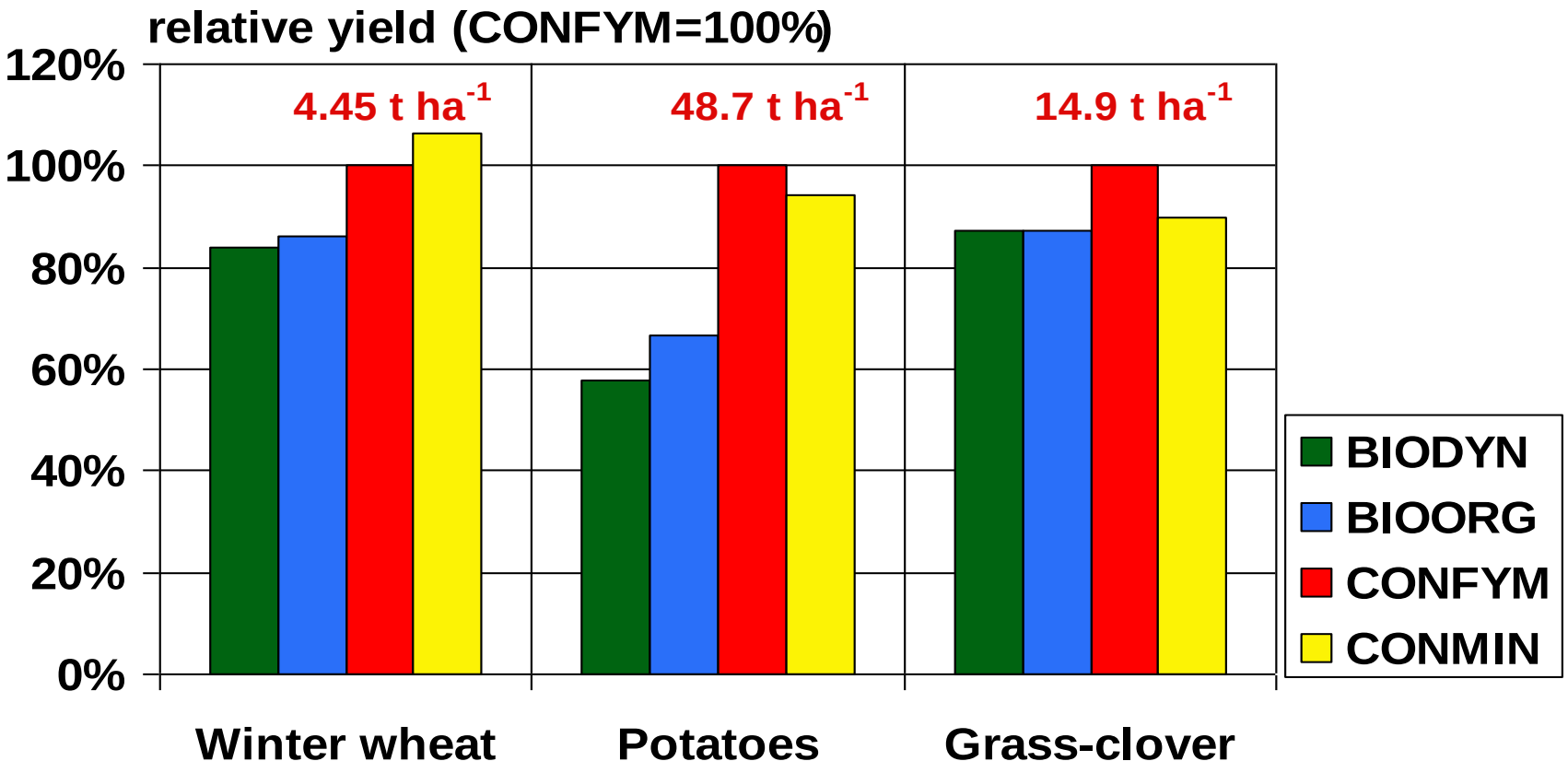
*1: low fertilization intensity (0.7 livestock units/ha)*

*2: normal fertilization intensity (1.4 livestock units/ha)*

# DOK trial - Input of nutrients (Ø 1978-2005)

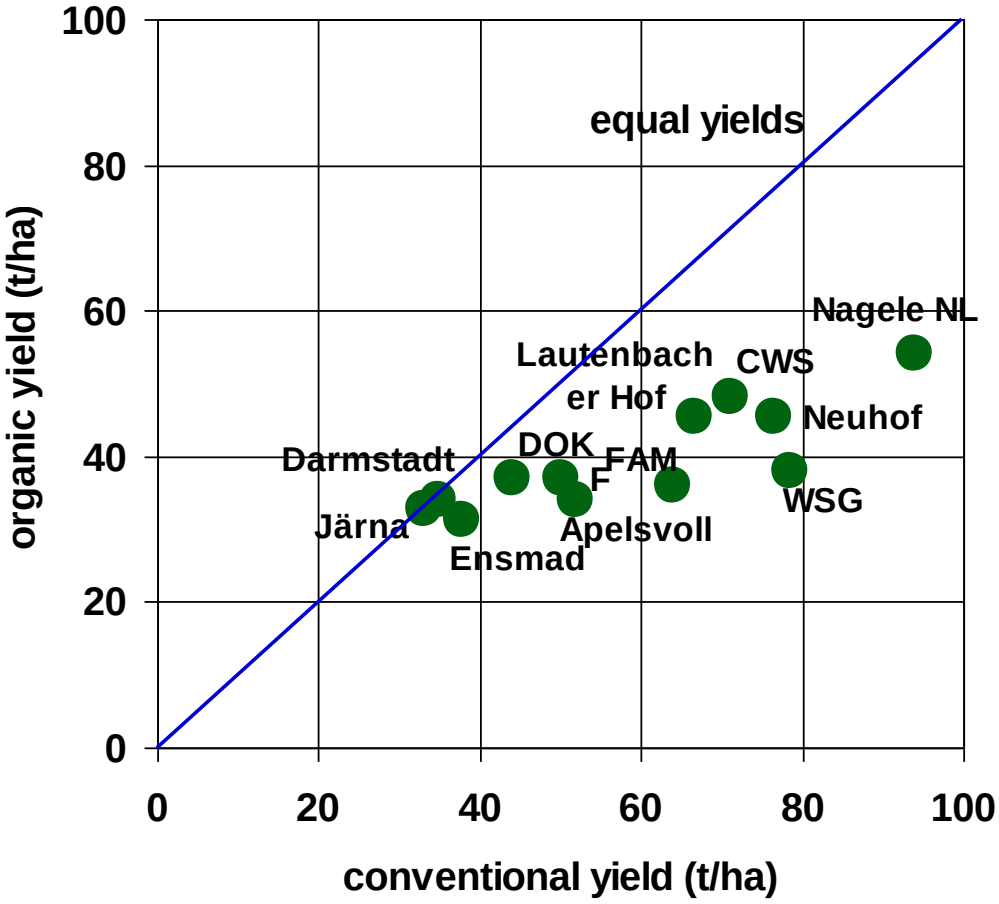


# DOK trial – Crop yield (Ø 1978-2005)




*Mäder, et al. (2006)*

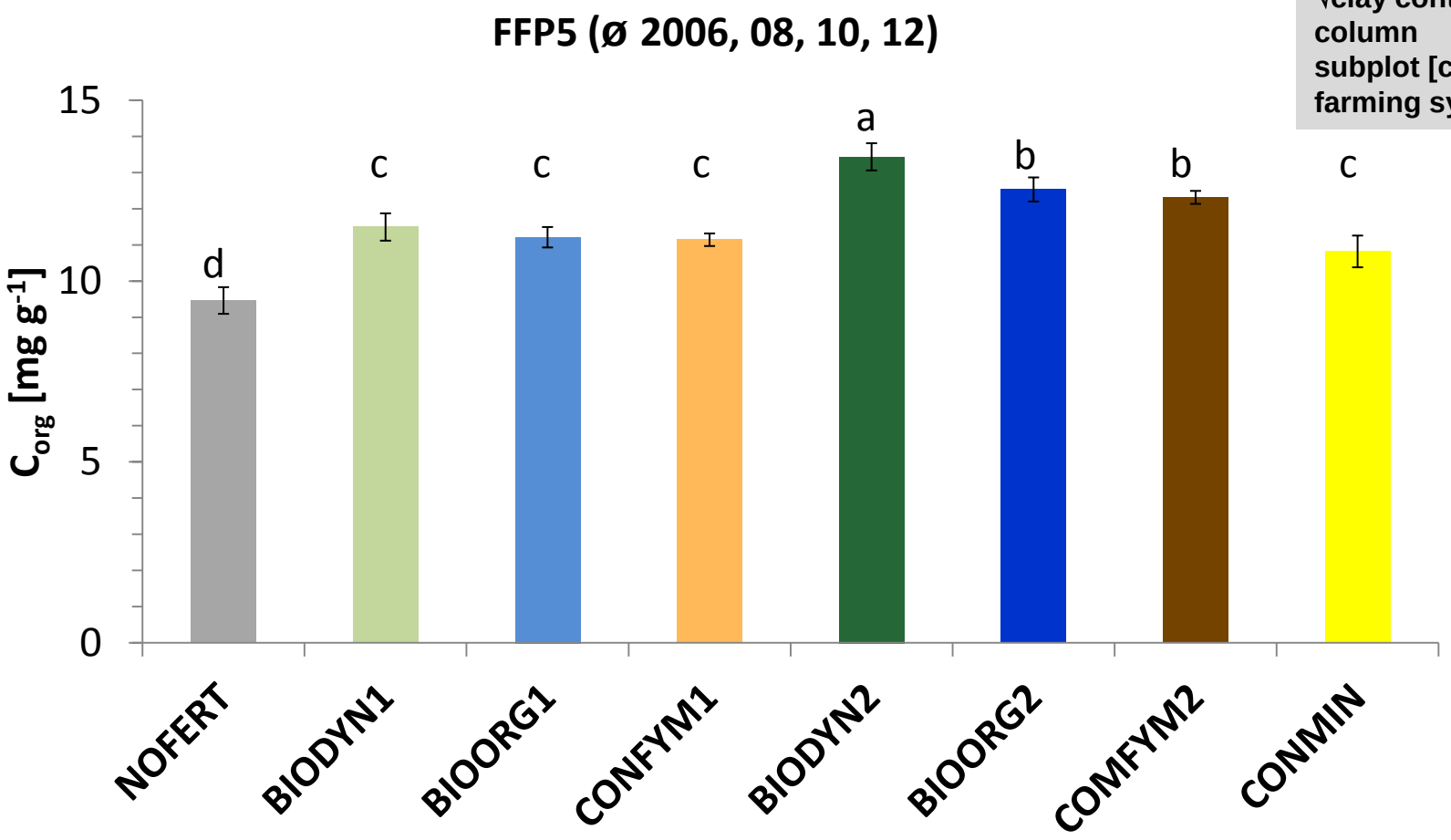
# Cereal yields in organic and conventional farming systems




*Piorr and Werner (1998) extended*

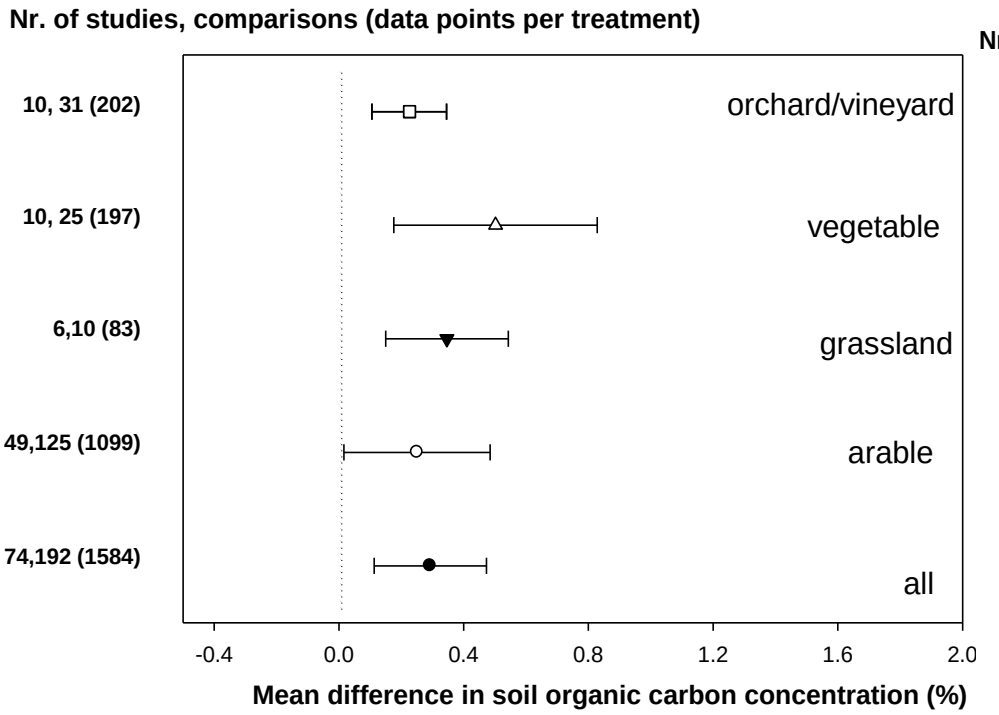
# Soil organic carbon in DOK farming systems

**Model for stats:**
**pH 1977**
**√clay content [%]**
**column**
**subplot [column]**
**farming system**

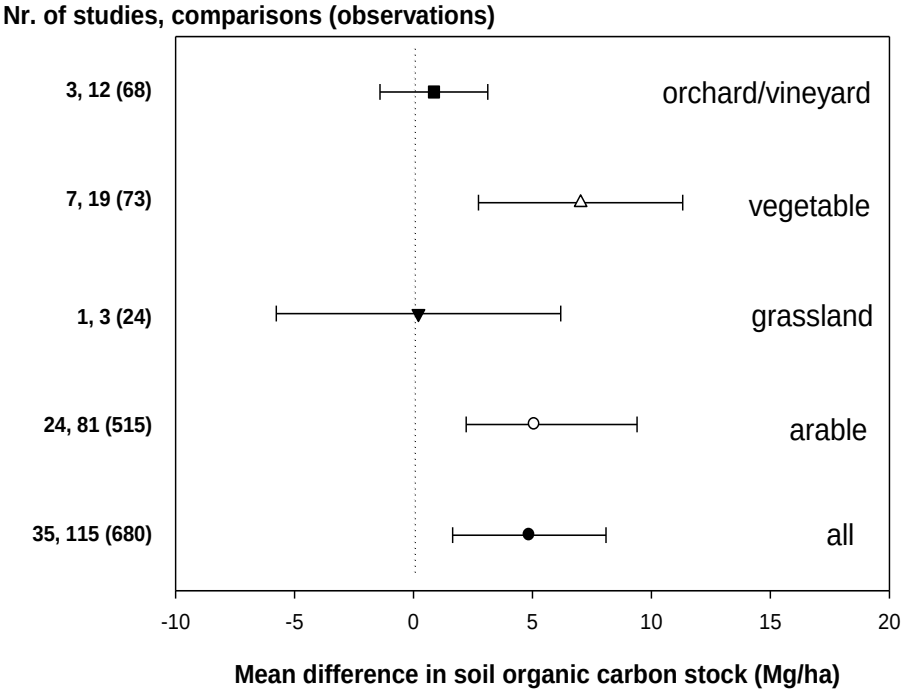


# Soil carbon in organic and conventional farming systems worldwide.

## Carbon content ($C_{org}$, %)



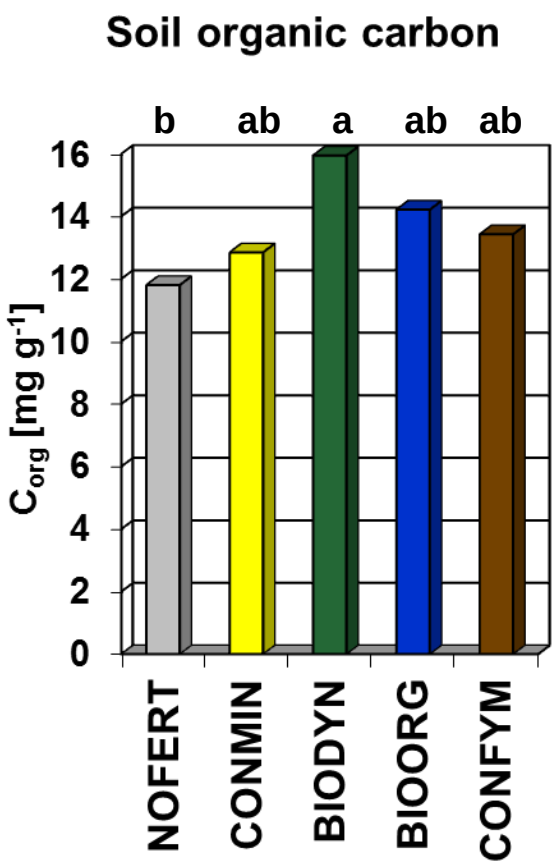

## C-stock (t $C_{org}$/ha)

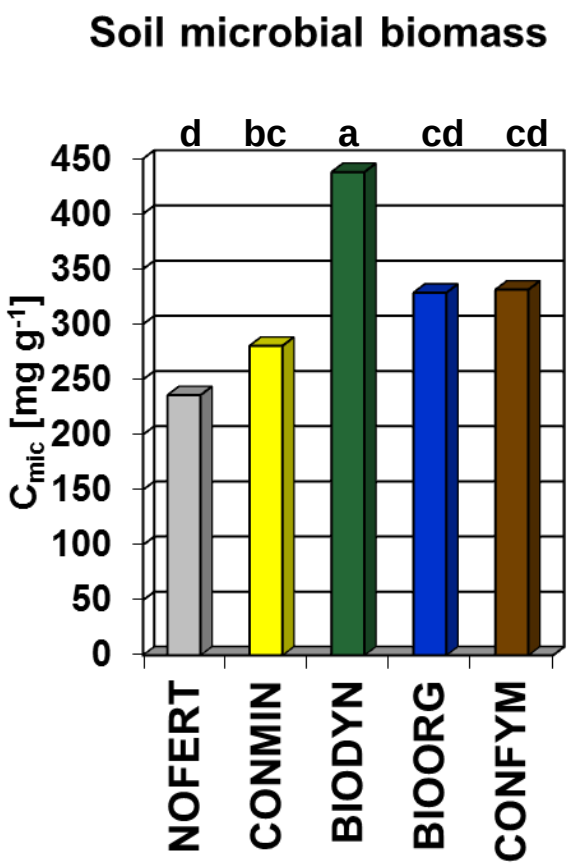


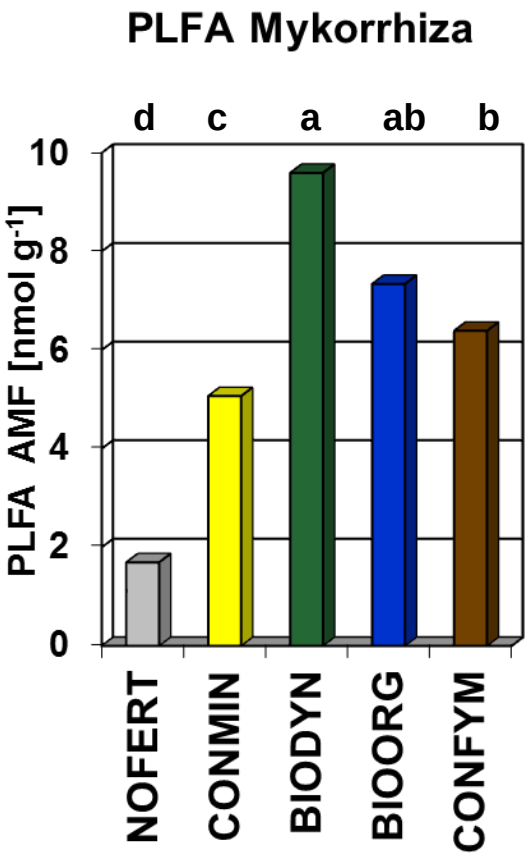



*Gattinger et al. PNAS (2012)*

# Sensitiveness of indicators (2004)

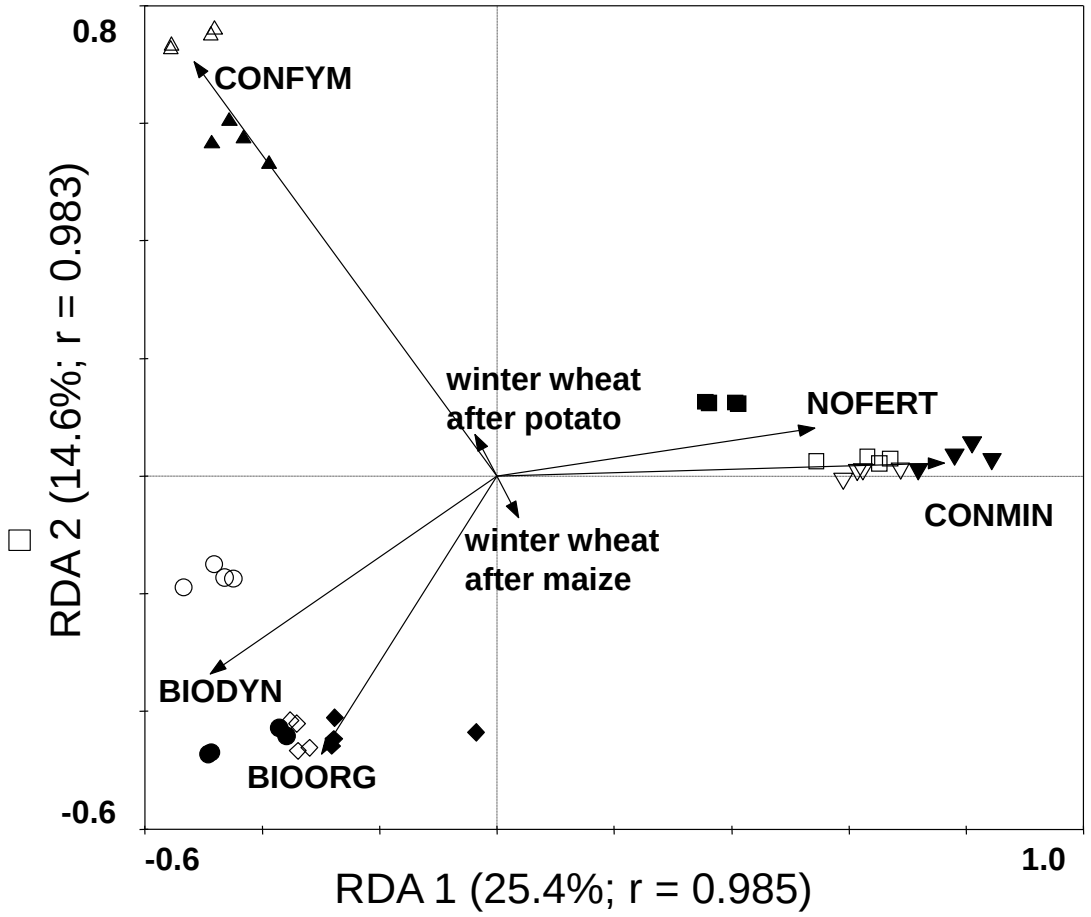



| | | | |
|---|---|---|---|
| Mais $\delta^{13}C$ | -26.79 | -25.81 | -25.41 |
| Soja $\delta^{13}C$ | -27.00 | -26.97 | -26.45 |

# RDA of PLFA profiles

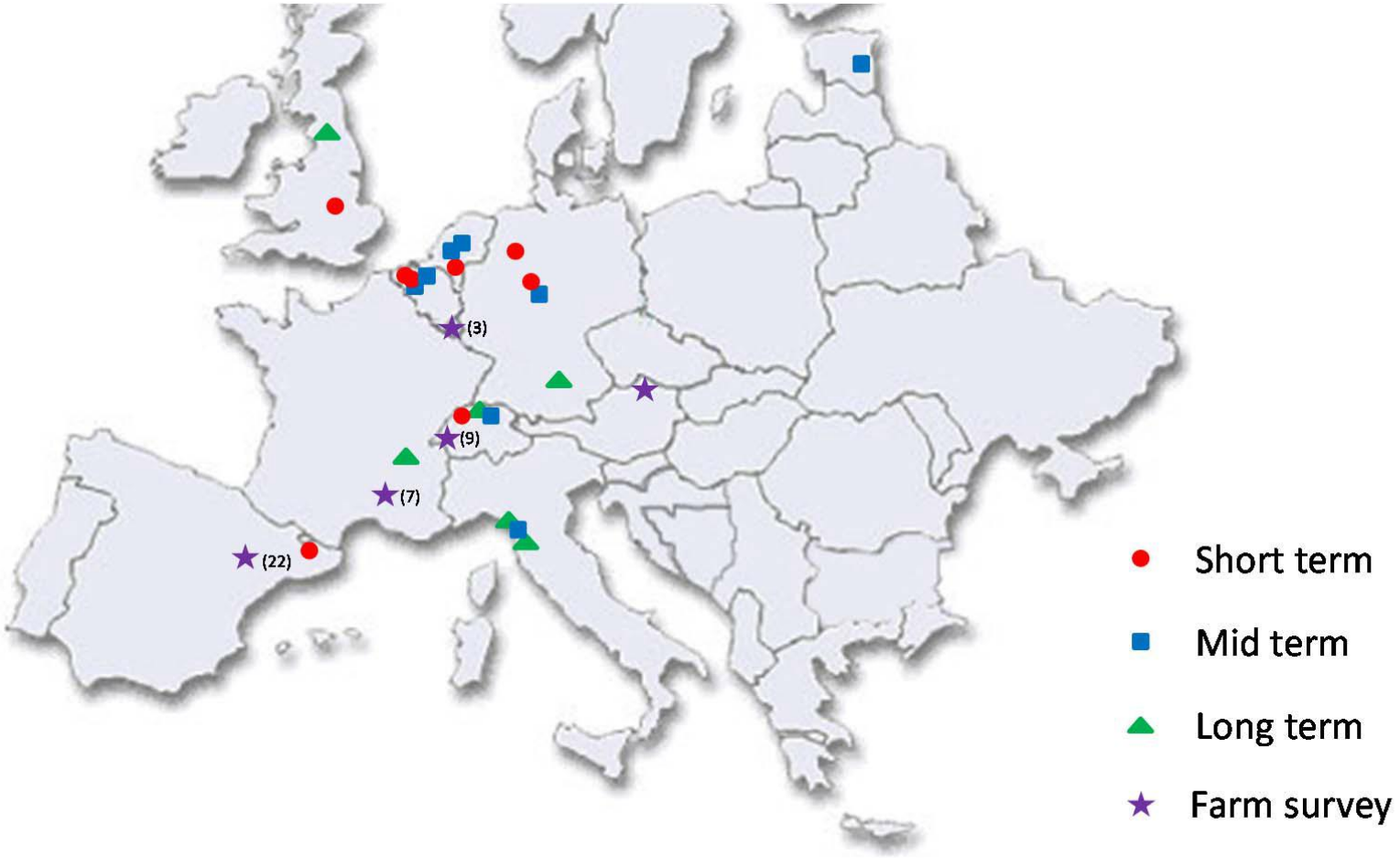



Constrained ordination of PLFA profiles in soils under winter wheat after potatoes (empty symbols) and after maize (filled symbols) in the DOK farming systems (□, ■ : NOFERT; ▽, ▼ : CONMIN; ○, ● : BIODYN; ◇, ◆ : BIOORG; △, ▲ : CONFYM)



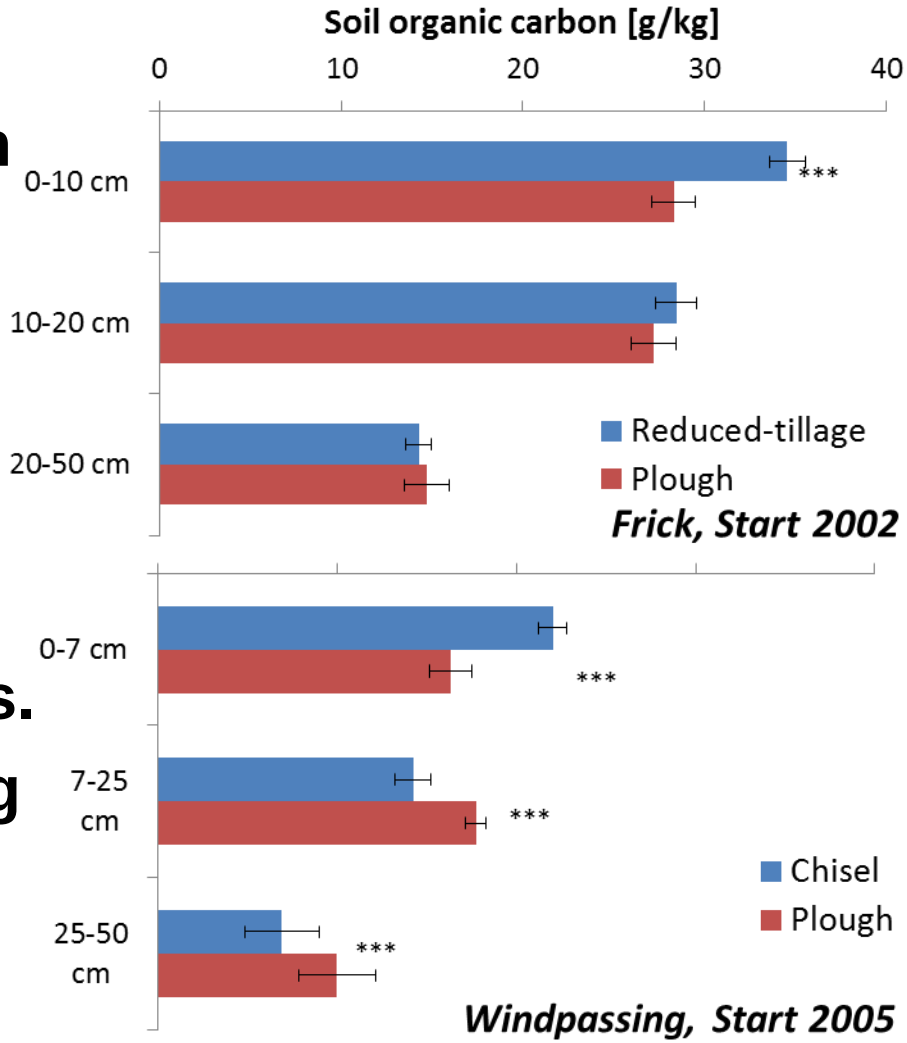
*Esperschütz et al, 2007 FEMS ME*

# Field trials and farm surveys under investigation in the European network TILMAN-ORG



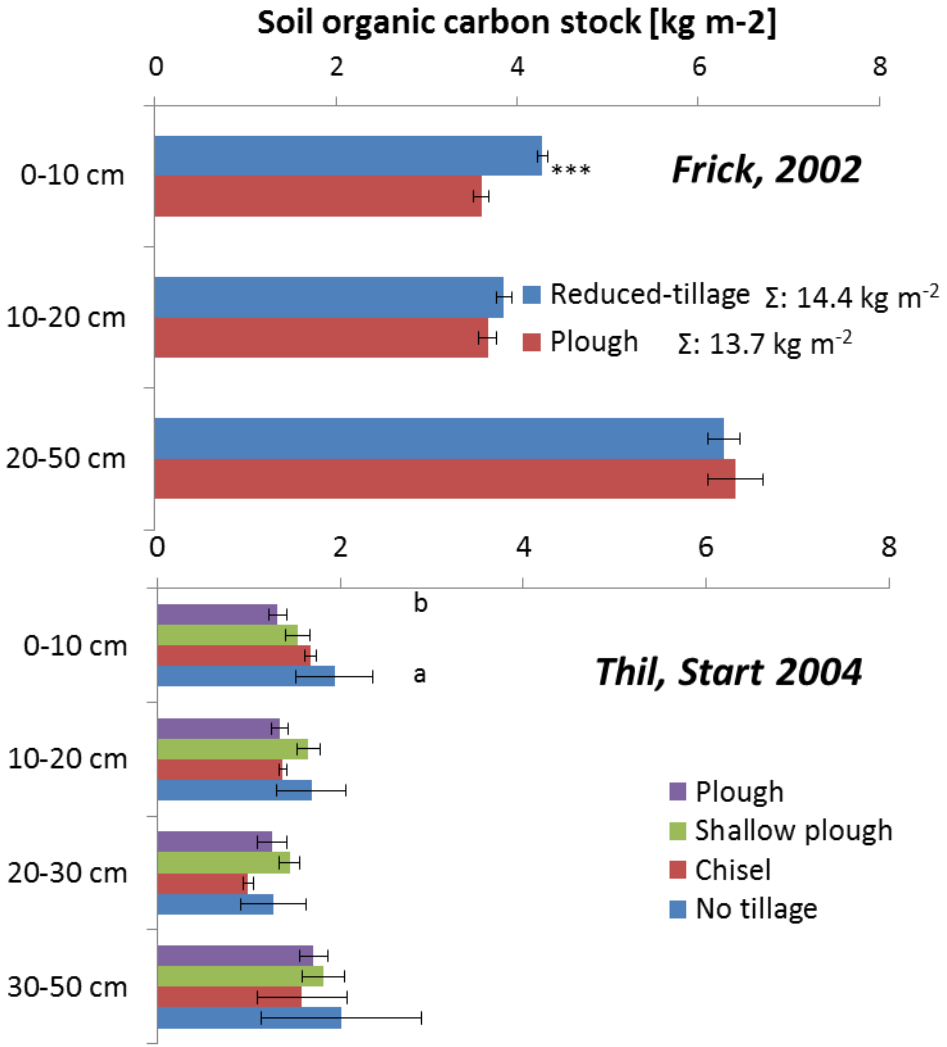
# Soil organic carbon vertical distribution

- Soil organic carbon content decreased with soil depth
- In most field trials reduced soil tillage enhanced soil organic carbon in the top soil, whilst no change occurred in deep layers.
- Exception Windpassing



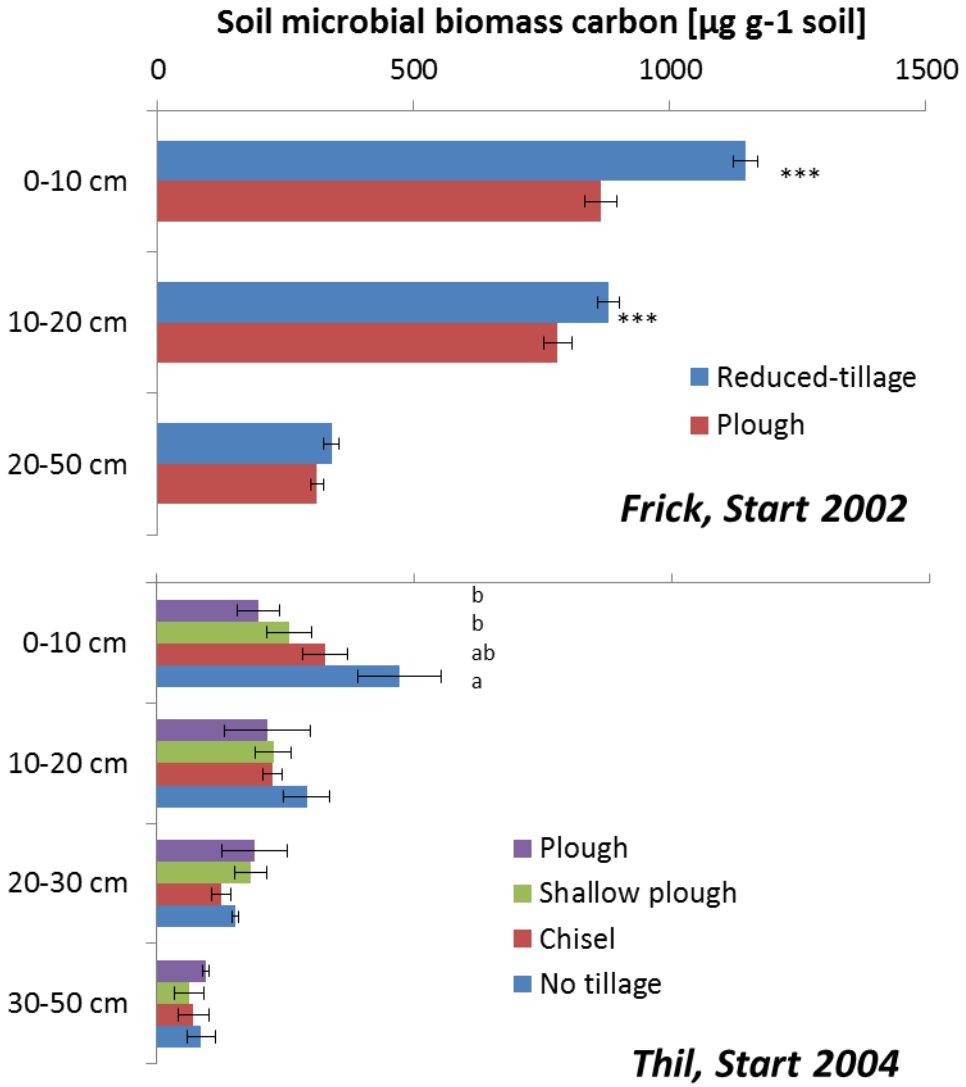
# Soil organic carbon stocks

- Soil carbon stocks in the soil layers were most often higher only in the top soil as shown for the trials in Frick and Thil (F).
- C-stocks over the whole profile were not significantly different between tillage systems, due to high variability in deep layers.



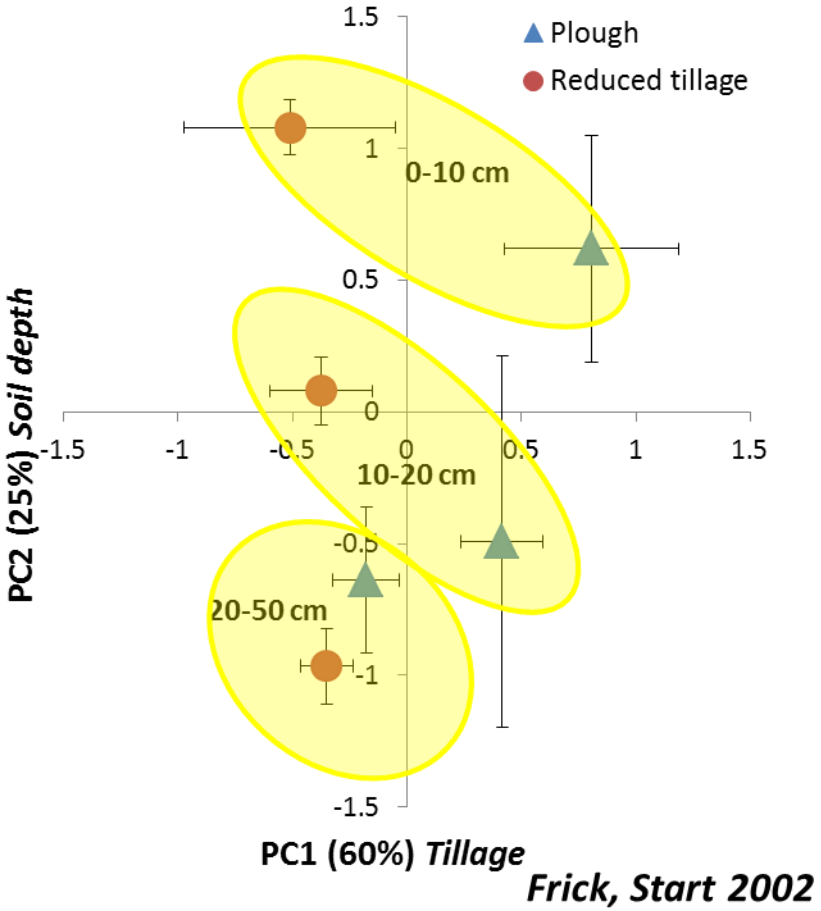
# Soil microbial biomass

- Compared to total organic C microbial biomass carbon showed differences between tillage systems clearer.
- This parameter seems to be a very sensitive with respect to the tillage treatments.



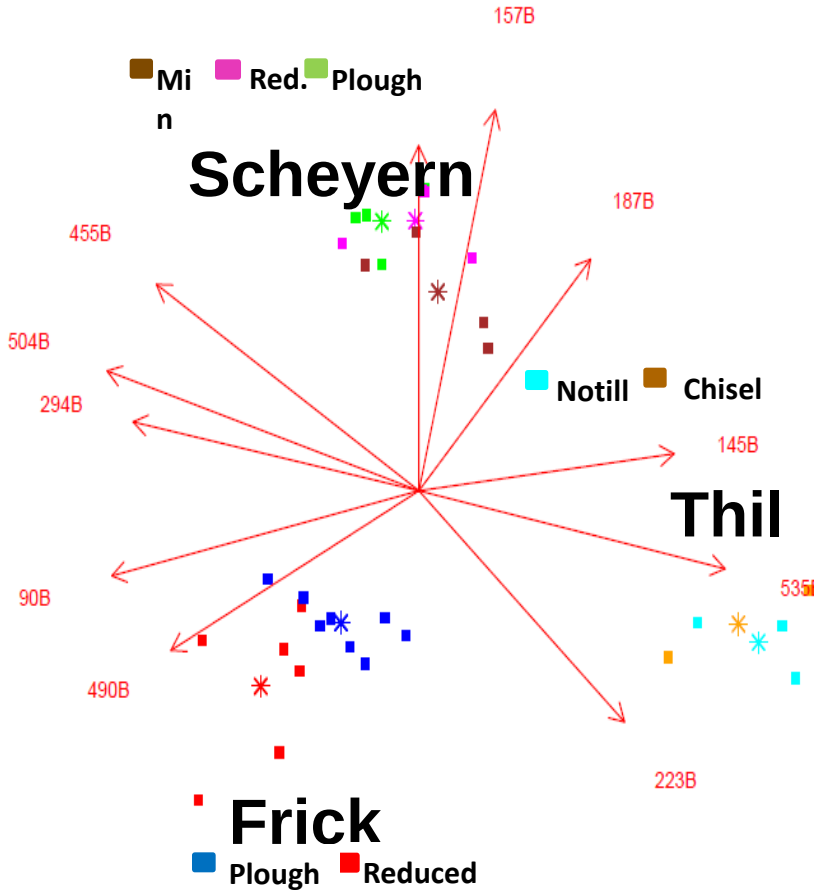
# Microbial community structure (PLFA)

- We identified more than 80 different PLFA in soil samples.
- The PLFA patterns in the top soil and the soil underneath were different, but identical in the undisturbed deep soil layers.



# Microbial community structure (DNA)

- **DNA patterns show clear distinction of sites.**
- **Bacteria and fungi react in a different way to tillage operations.**
- **Proteobacteria and Fermicutes were already identified to respond to tillage systems.**



# Greenhouse gas fluxes influenced by tillage

## Van Kessel et al. (2013)

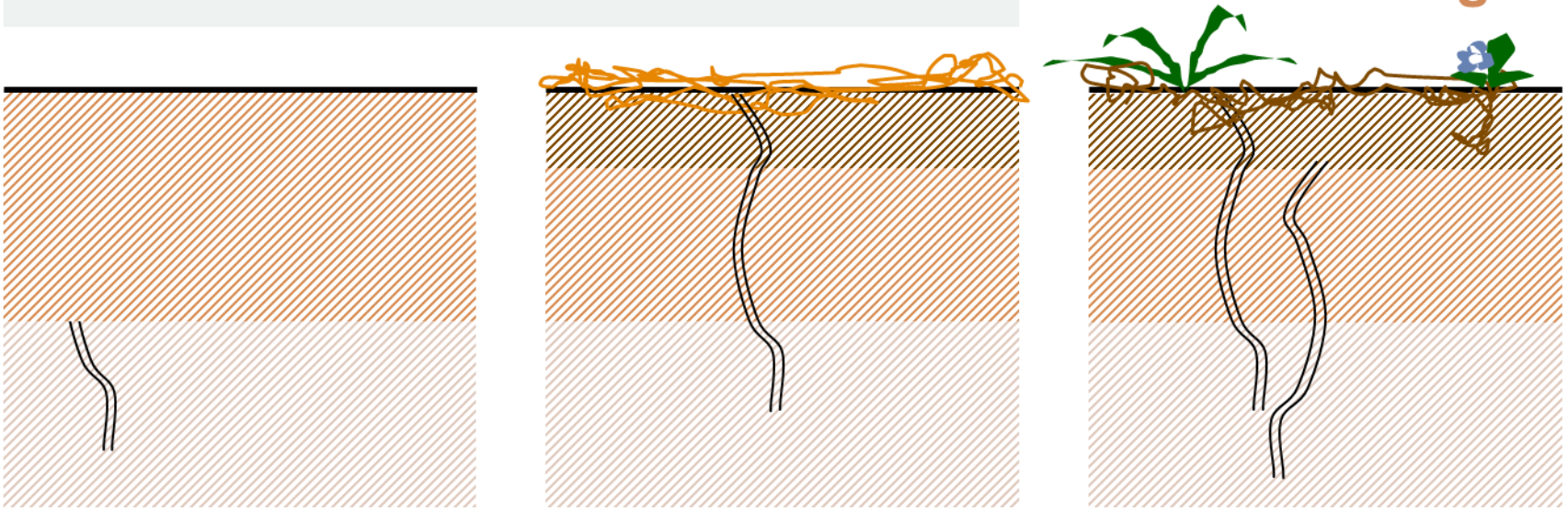
- No difference in $N_2O$ emissions after 10 years in temperate regions

ploughing

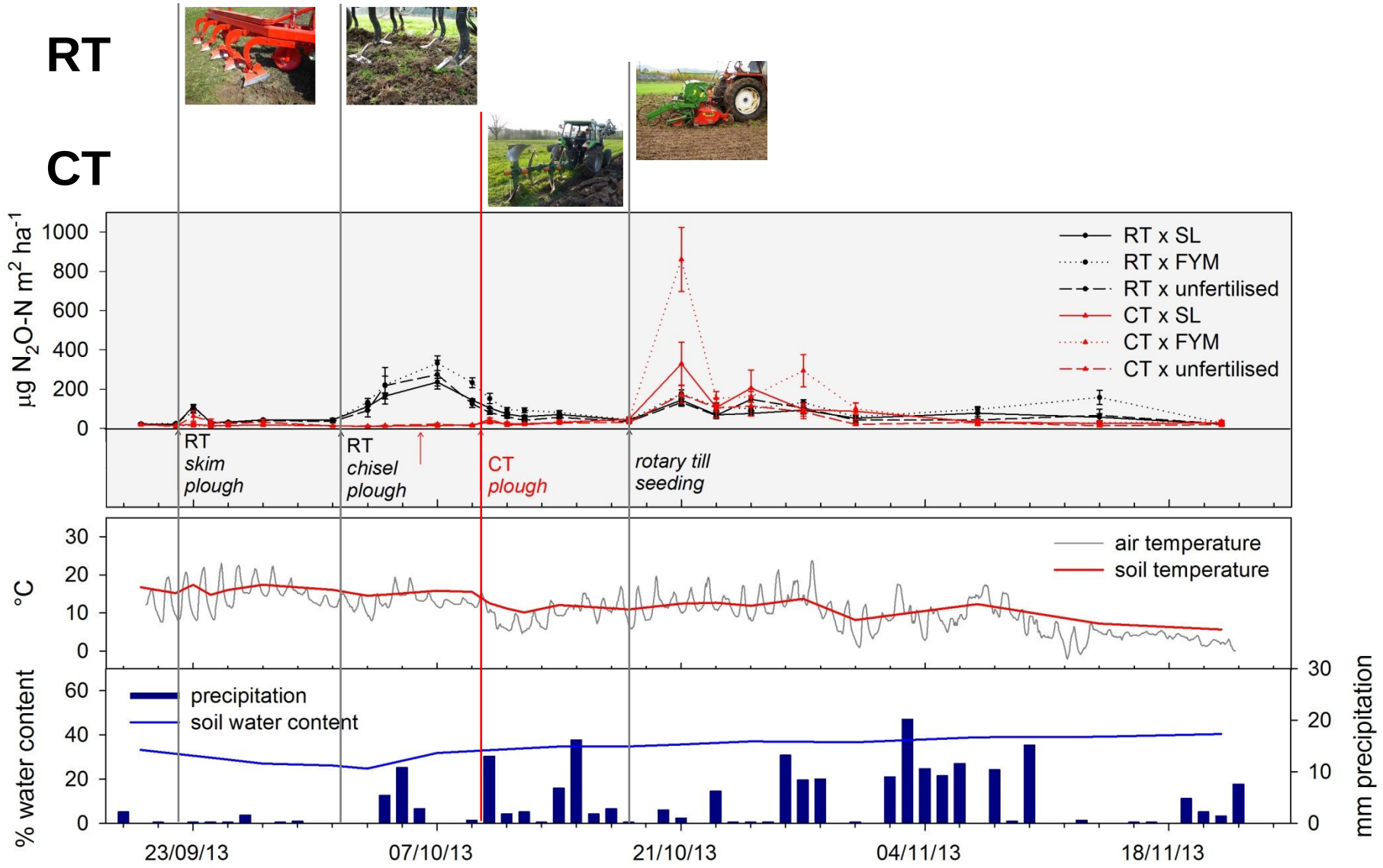
no-till with herbicides

?

organic reduced tillage



# Organic ley destruction with reduced tillage




Kraus et al., 2013, unpublished

# Conclusions

- The DOK trial showed higher efficiency of fertilizer use in organic systems at the same level of organic manure input.
- Soil carbon and microbial biomass were higher in the biodynamic system with compost fertilization.
- Soils had distinct microbial communities.
- Soils under reduced soil tillage showed improved soil quality especially in the uppermost soil layer, with important implication for soil stability and erosion.
- Fungi and bacteria in soils react in a different way to soil disturbance by tillage.
- Field monitoring of greenhouse gas emissions showed again the importance of pulses. After management events (fertilization, weeding, grass-clover destruction) pulse emissions followed.

# Acknowledgements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