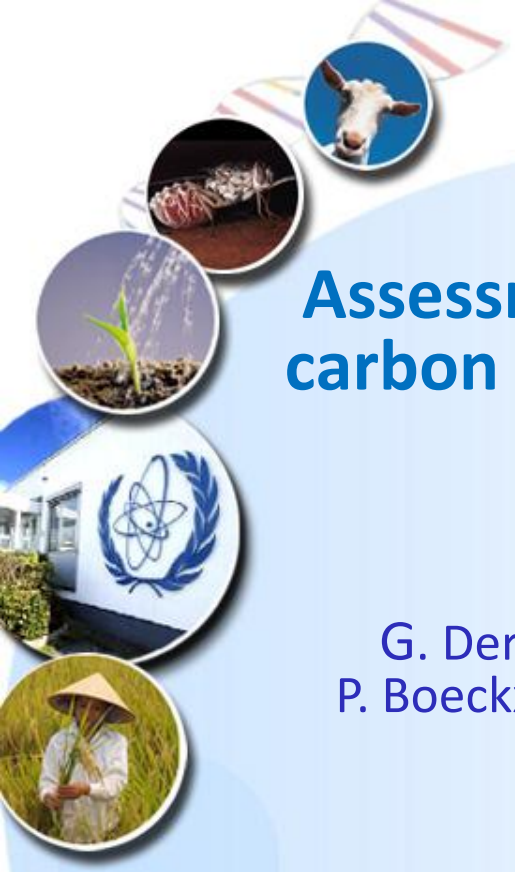


Assessment of carbon distribution and soil organic carbon storage in mulch-based cropping systems by using isotopic techniques

G. Dercon[1], M. Heiling[1], M. Aigner[1], L. Mayr[1], C. Resch[1], S. Bodé[2], P. Boeckx[2], J. Arrillaga[1], P. Cepuder[3], G. Bodner[3], R. Nolz[3], H. Bock[4], H. Spiegel[4], J. Adu-Gyamfi[1], M.L. Nguyen[1]

[1] International Atomic Energy Agency, Austria
[2] Isotope Bioscience Laboratory, Ghent University, Belgium
[3] University of Natural Resources and Life Sciences Vienna (BOKU), Austria
[4] Austrian Agency for Health and Food Safety (AGES), Austria

Background

Better understanding is needed about …

… how soil organic carbon (SOC) accumulation and storage is influenced by:

- Crop residues
- Root development

… factors controlling turnover and stability of the stored SOC, particularly in the deeper soil layers

… linkage between nitrogen inputs to soil and SOC sequestration

… transfer phase from conventional to no-tillage mulch-based systems

Coordinated Research Project D1.50.12

Title: **„Soil Quality and Nutrient Management for Sustainable Food Production in Mulch-based Cropping Systems in Sub-Saharan Africa“**

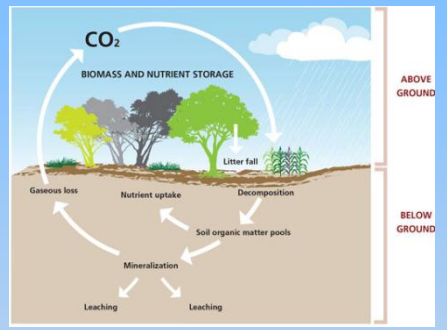
Objective:

- ✓ To pilot test soil management and agronomic practices in mulch-based agricultural systems that aim
  - to (i) restore soil fertility, optimize ecosystem service efficiency and increase agricultural productivity,
  - while (ii) enhance adaptation and mitigation to climate change in these systems in Sub-Saharan Africa

Duration: 2011 - 2016, 15 participants

Need for analytical tools …

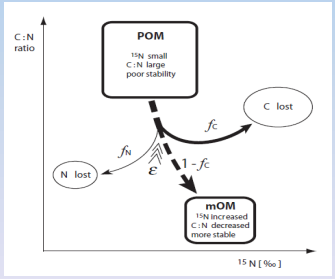
- To monitor the **impact** of complex land management strategies in **enhancing SOC accumulation and storage**
- To assess **carbon distribution** in the soil profile under **on-farm conditions**
- To **quantify stability** of the stored SOC in agro-ecosystems



Proposed analytical tools are based on …

- Multiple **isotope** based (^{13}C, ^{14}C and ^{15}N) **tracing techniques**
  - At natural abundance and enriched levels
  - Bulk soil and plant samples
  - SOC fractions
  - Specific organic compounds (^{13}C in fatty acids) for SOC origin

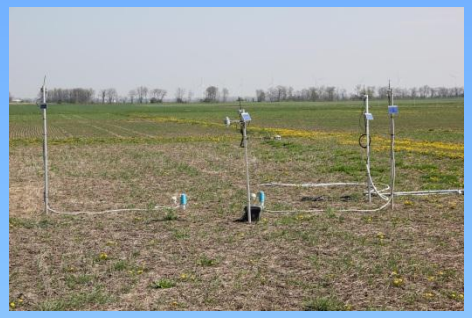
- Adaptation of **modelling tools** for assessment of SOC stability or determining SOC origin



SWMCN Laboratory Research Activities

Field experiments

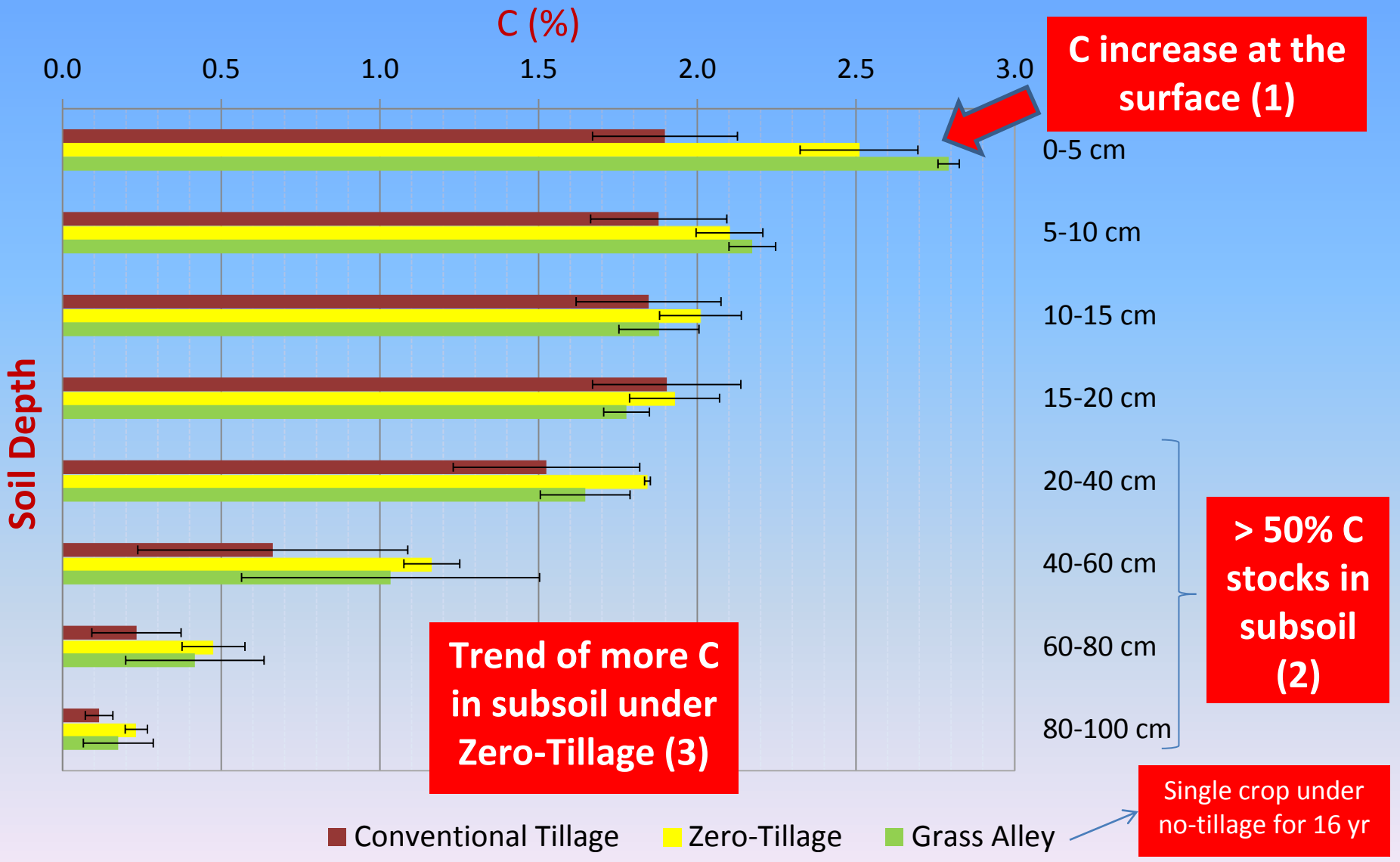
1. *Groß-Enzersdorf (16 years long-term trial): Chernozem, with SOC (> 2%) – 10 km East from Vienna;*



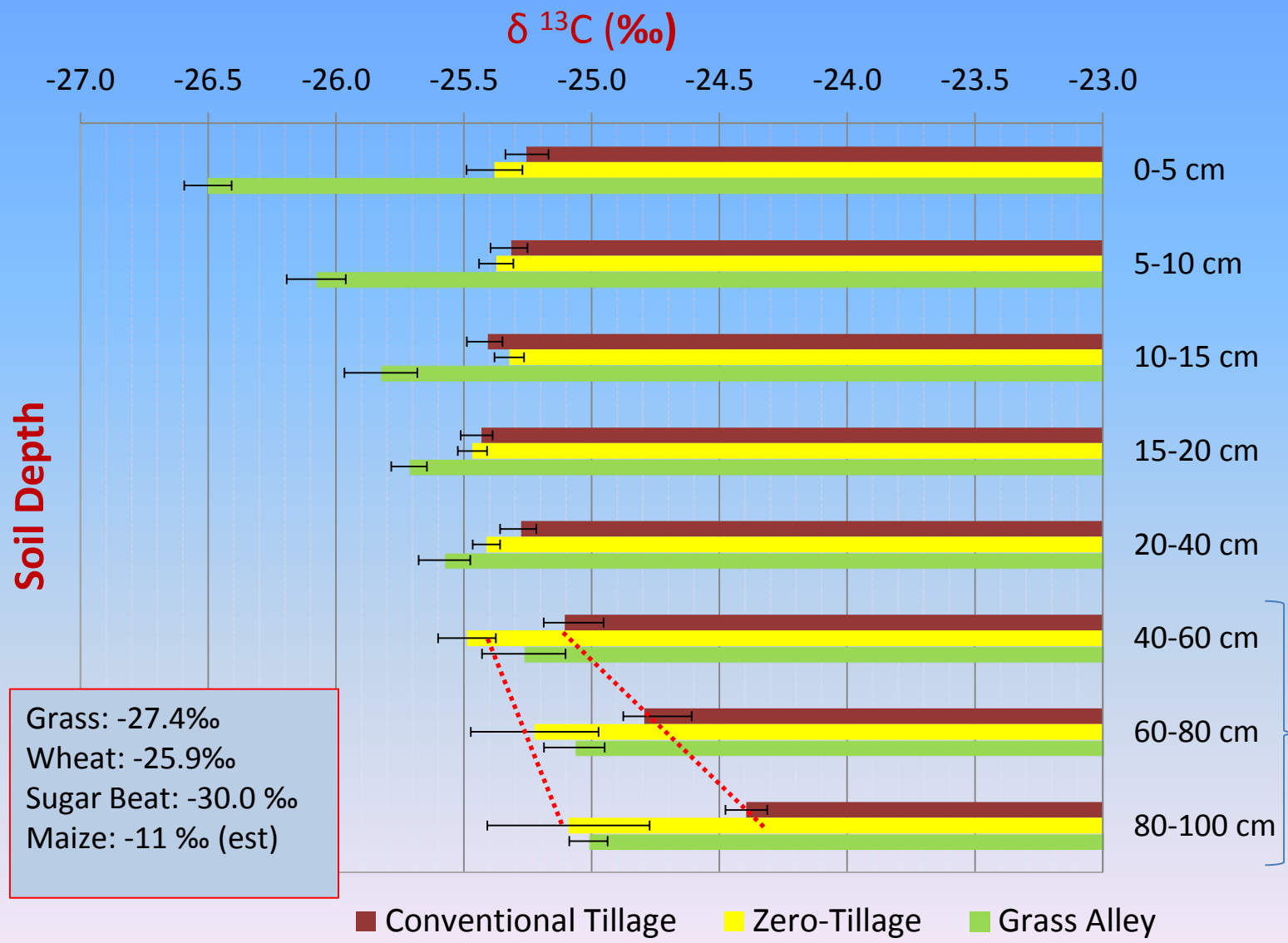
2. *Grabenegg: Cambisol , with SOC content (1-1.5%) – 116 km West from Vienna*

Greenhouse experiments on two contrasting soils (Seibersdorf FAO/IAEA Laboratories)

Carbon Distribution in Chernozem (Gross-Enzersdorf, Austria)



δ ^{13}C profile in Chernozem (Gross-Enzersdorf, Austria)

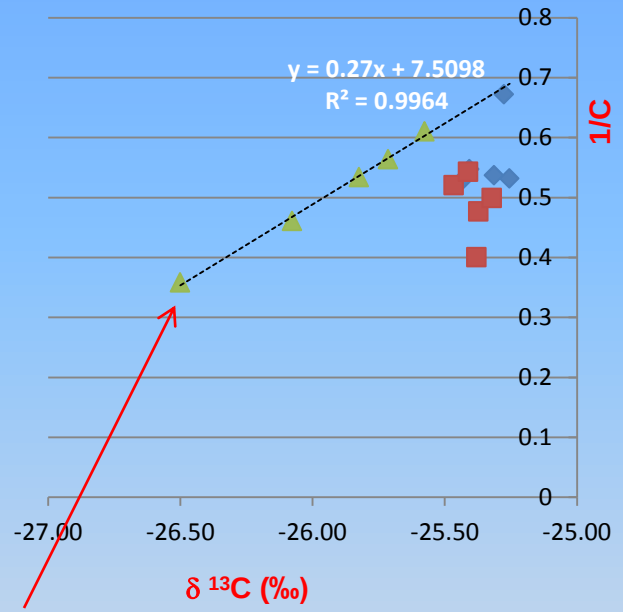


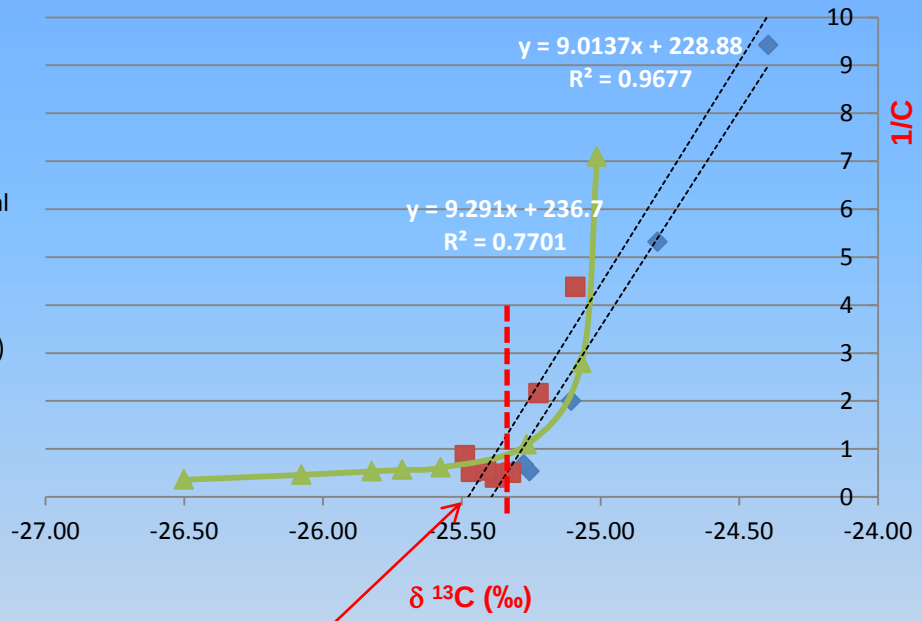
Grass: -27.4‰
Wheat: -25.9‰
Sugar Beat: -30.0 ‰
Maize: -11 ‰ (est)

Shift in δ ^{13}C signature in the deep soil under different tillage systems

Carbon contribution in Chernozem (Gross-Enzersdorf, Austria)

Application of Balesdent Model (1990) for new and old carbon inputs





Intercept for X- axis = -27.8 ‰
(new carbon inputs under grass alleys)

Intercept for X- axis = -25.4‰
(new carbon inputs under cultivated plots)

?

Fresh carbon:
Grass: -27.4‰
Wheat: -25.9‰
Sugar Beat: -30.0 ‰
Maize: -11 ‰ (est)

?

Carbon contribution in Chernozem (Gross-Enzersdorf, Austria)

Application of Balesdent Model (1990) for new and old carbon inputs

Under the alley (after 16 years):

Proportion of old carbon:

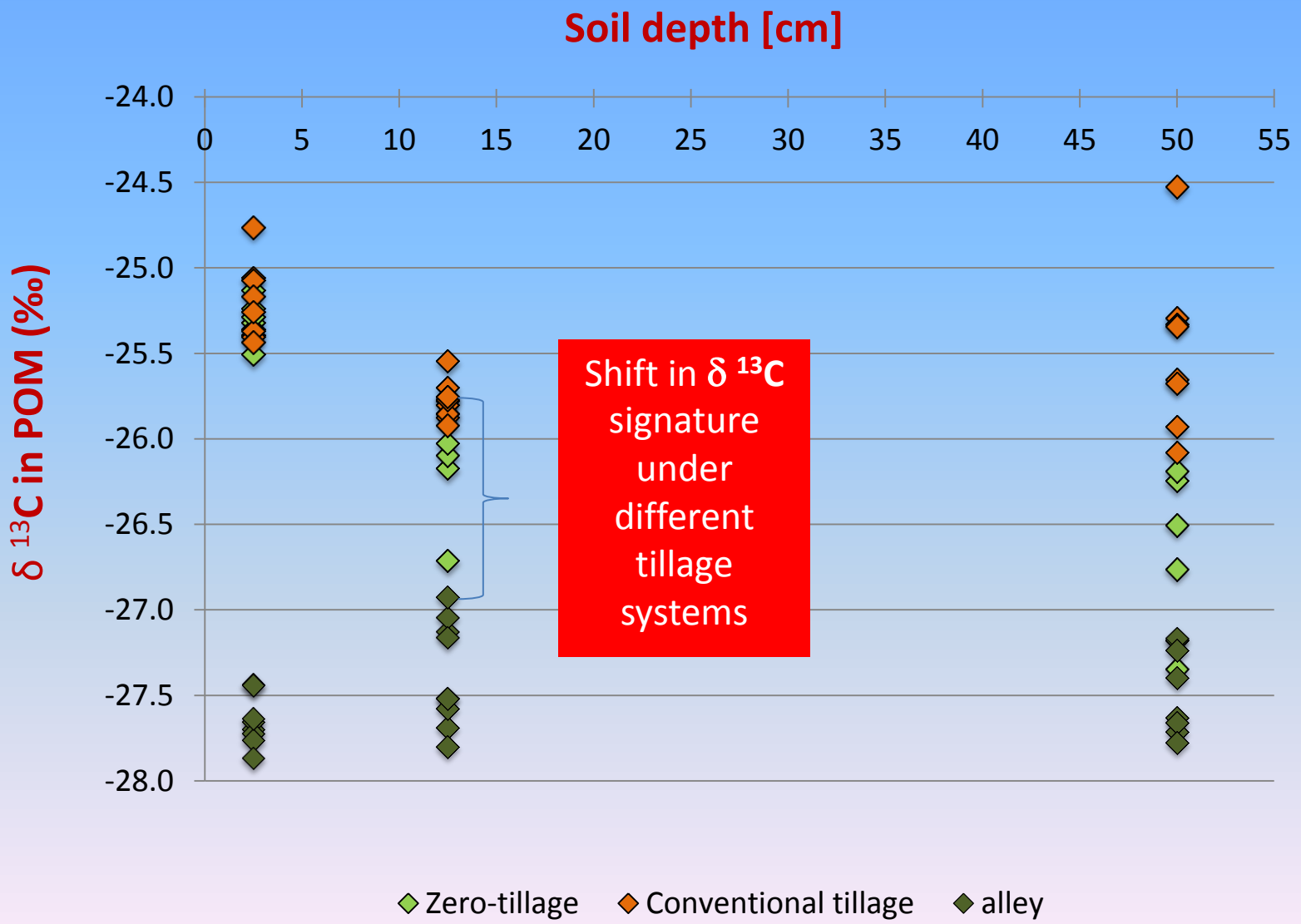
0-5 cm	54%
5-10 cm	71%
10-15 cm	82%
15-20 cm	86%

….. Can we determine the proportion of carbon inputs by different crops in rotations by using $\delta^{13}C$ signature (‰) of specific compounds?

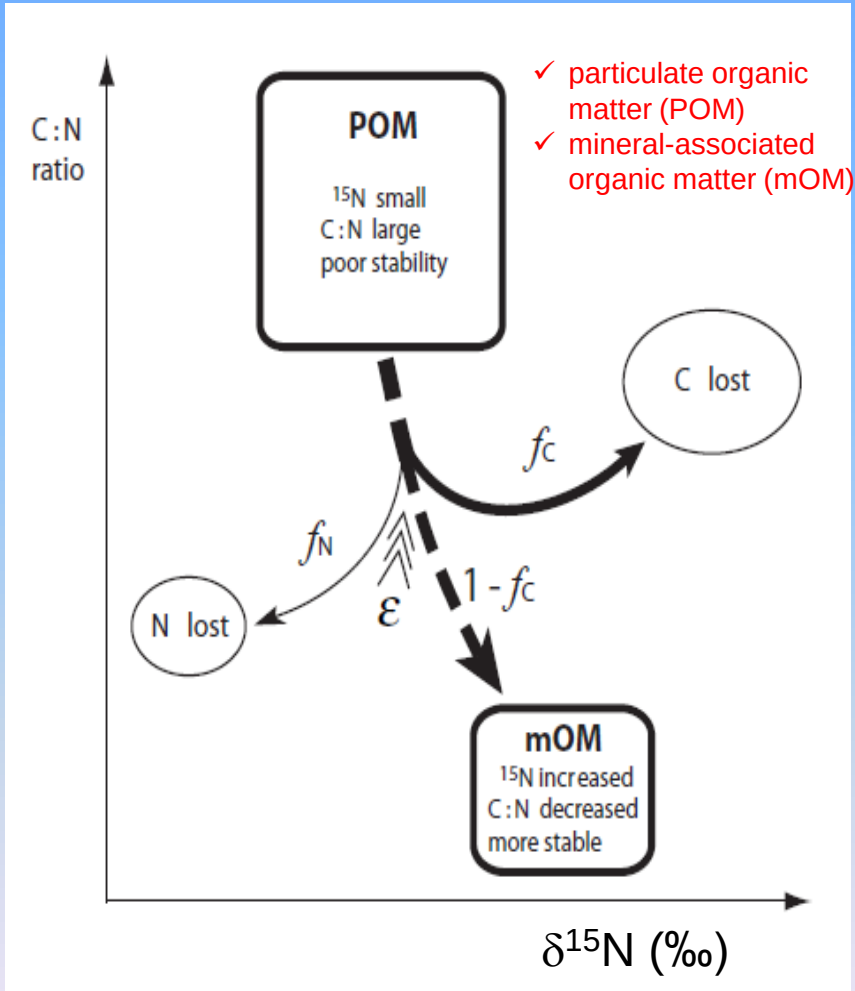
Soil Depth	Conventional tillage		Zero tillage		Grass alleys	
(cm)	C16:0	C18:0	C16:0	C18:0	C16:0	C18:0
0-5	–31.3 ± 2.7	–29.7 ± 0.7	–31.2 ± 1.6	–30.2 ± 0.6	–31.4 ± 0.7	–31.3 ± 0.9
10-15	–31.2 ± 1.9	–29.9 ± 0.1	–32.2 ± 2.1	–30.2 ± 0.9	–32.0 ± 1.6	–30.4 ± 0.2
40-60	FA concentrations too low		FA concentrations too low		FA concentrations too low	

✓ Low concentrations in the deeper soil
✓ Better extraction techniques?
✓ Additional specific compounds

Shift in δ ^{13}C signature in Particulate organic matter (POM) Fraction?



Assessing Soil Organic Matter (SOM) Stability



Conen et al., 2009

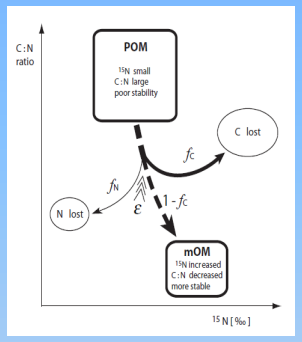
C:N ratio of SOM decreases with decomposition and re-synthesis:

- ✓ N-rich organic compounds are utilised as a C source
- ✓ Excess N is mineralised
- ✓ Leading to ^{15}N enrichment of the remaining substrate

Developed for undisturbed ecosystem conditions, but what for agro-ecosystems?

- ✓ Fertilizer-N inputs
- ✓ N dynamics
- ✓ Steady state?

First application of Conen model (Grabenegg – Soil, Gleyic Cambisol)



	$\delta^{15}N$ mOM	$\delta^{15}N$ POM	C/N	C/N
	[delta]	[delta]	mOM	POM
mean	**6.693**	**4.695**	**8.19**	**14.00**
stdev	*0.008*	*0.157*	*0.02*	*0.23*

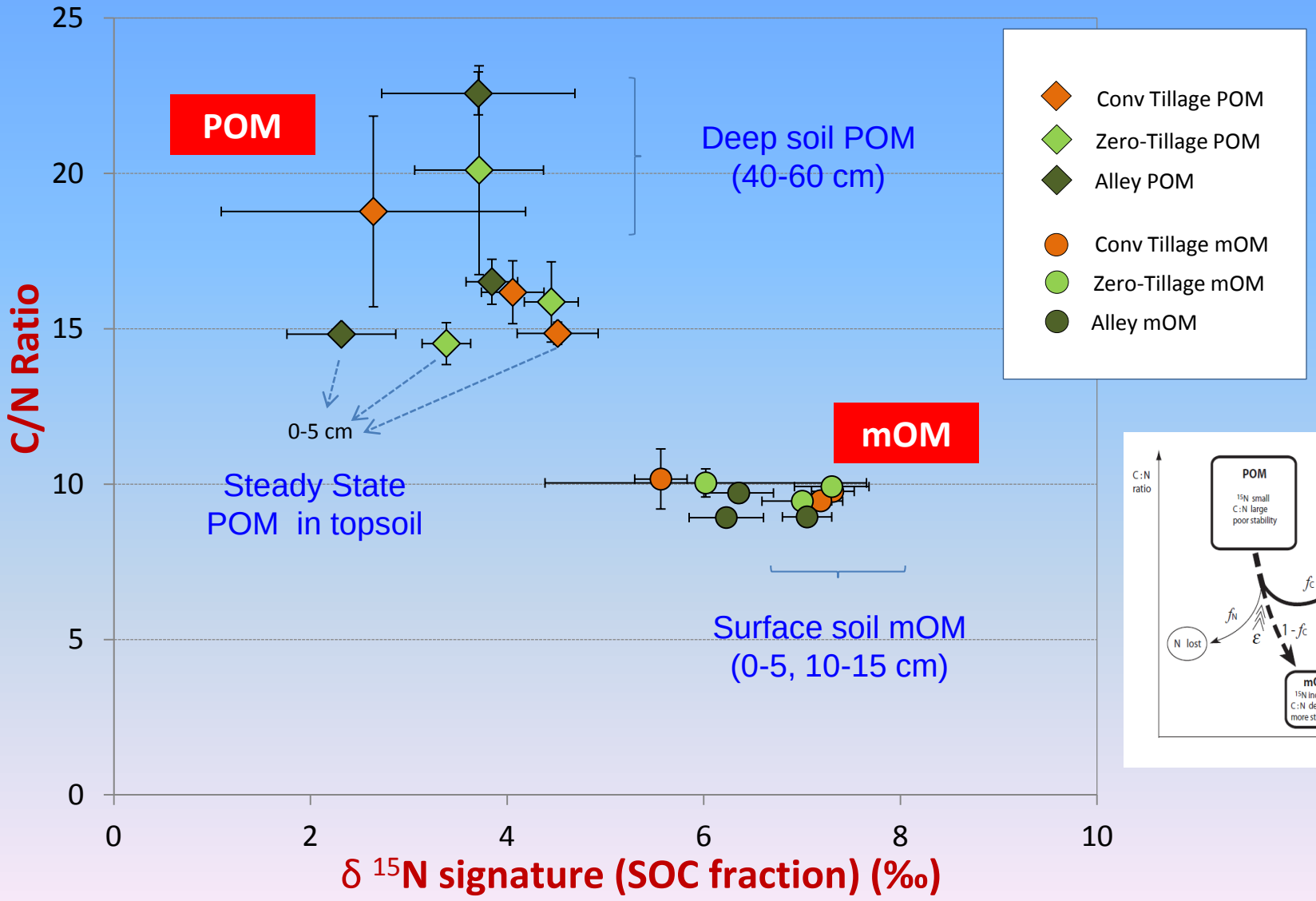
Promising results!
- ✓ For mOM $\delta^{15}N$ increased
- ✓ C:N decreased
- ✓ Good repeatability, in topsoil (less in subsoil)

	ε -2	**ε -5**
	n	n
mean	**107**	**58**
stdev	16	7

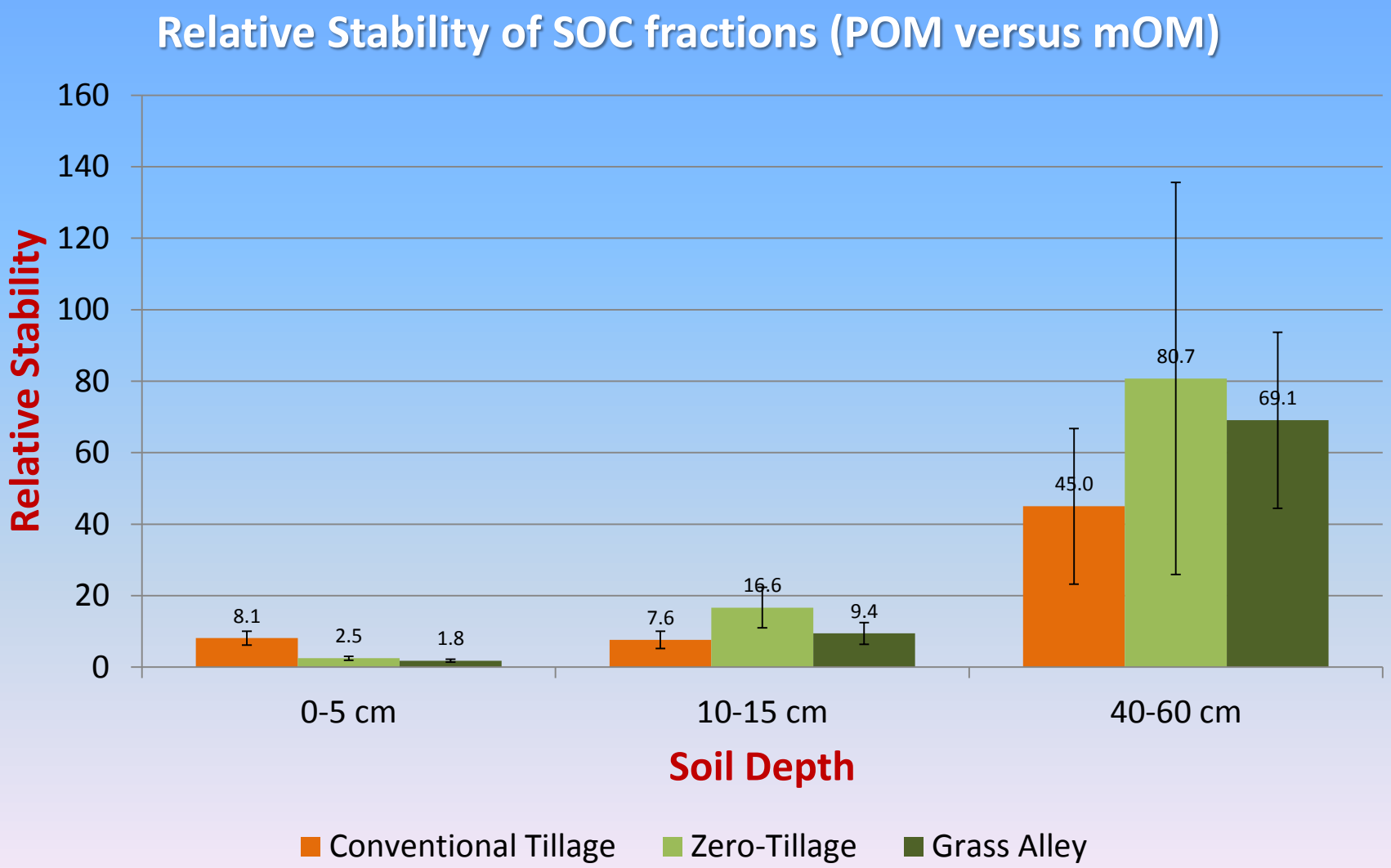
Validation through ^{14}C-dating is needed to find the right ε (enrichment factor)

ε is the critical factor
(~ isotopic fractionation)

Conen model application in Chernozem (Gross-Enzersdorf, Austria)



Conen model application in Chernozem (Gross-Enzersdorf, Austria) – (2)



Way forward

- **Better understanding** of soil organic carbon sequestration and storage in mulch-based cropping systems
- **Isotopic tools** for field-based assessment on soil organic carbon sequestration and stability
- **Training** CRP – TC project participants in isotopic techniques for soil organic carbon assessment

Many thanks for your attention!

CRP D1.50.12 and SWMCN team