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in situ ^{13}C pulse labelling and tracing

Methodological approach and challenges for application in cover crop research

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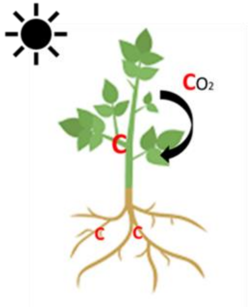
October 2024

The fate of above and belowground CC carbon inputs in soil

Four different cover crops <u>revelant</u> for cereals production in Norway

Feature	Italian Ryegrass (*Lolium multiflorum*)	Oilseed Radish (*Raphanus sativus*)	Summer Vetch (*Vicia sativa*)	Phacelia (*Pha. tanacetifolia*)
C:N ratio	Shoots: 29 Roots: 51	Shoots: 50 Roots: 75	Shoots: 14 Roots: 34	Shoots: 23 Roots: 65
Root System	Fibrous, dense root system	Deep taproot	Deep, fibrous roots with nitrogen-fixing nodules	Fibrous root system
Maturity	Quick to establish	Fast-growing	Fast-growing	Fast-growing
Physiology	Non-leguminous grass, high biomass producer	Non-leguminous, brassica family	Leguminous	Non-leguminous

Bárcena et al., under preparation



2021

sequestering CO_2 from the atmosphere

Growing CC

1st sampling (plant&soil)

2021

Incorporation CC

2022

2023

C persistence into soil

2nd soil sampling

3rd soil sampling

summer/spring | autumn | autumn | autumn | autumn

Bárcena et al., under preparation

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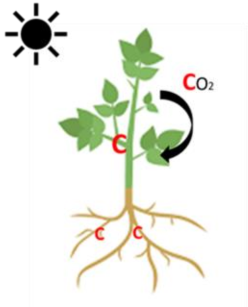

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Cover crop growing conditions

Trace belowground C originating from each individual species

- Monoculture;
- 120 kg N /ha;
- Liming;
- Weeding and irrigation;
- Sowing: end april;
- Harvest: september;

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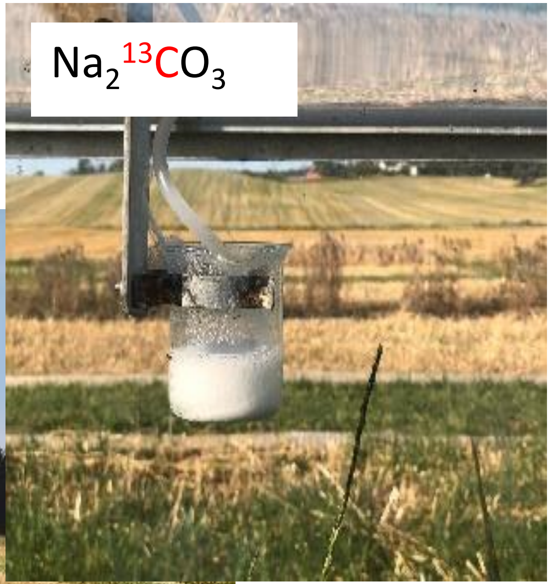
In situ ^{13}C pulse-labelling

June – September



Summer vetch
5 pulse labelling

Phaselia
5 pulse labelling

I.Ryegrass
6 pulse labelling

O. radish
5 pulse labelling

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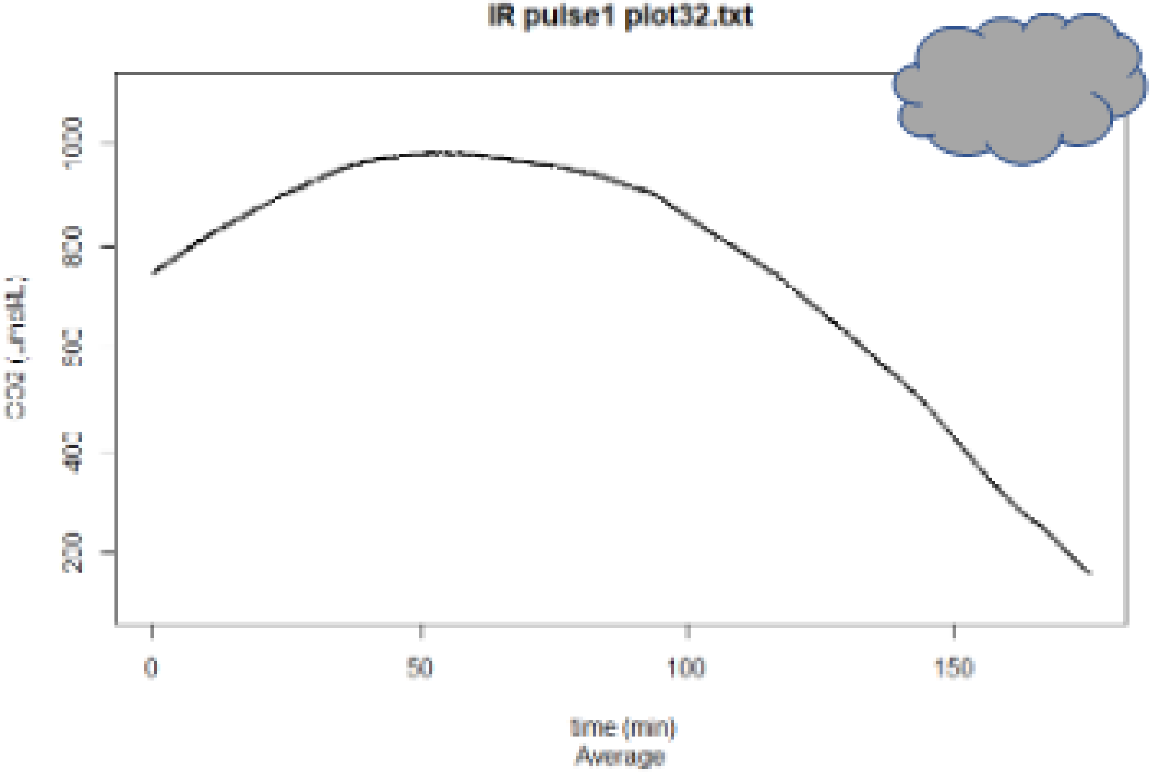
Bárcena et al., under preparation

CO_2 uptake monitored with an Infra-Red Gas Analyzer



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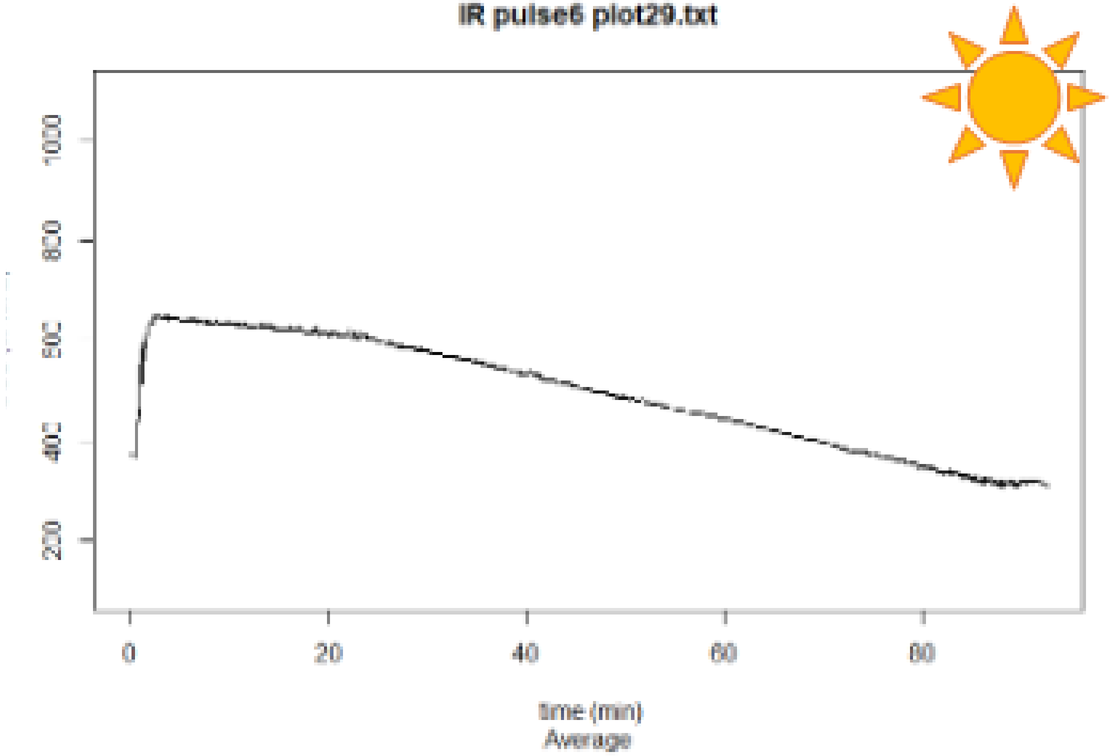
Wether : cloudy

DAP : 63



Date, time : 2021-09-01, 9:36:32

Wether : sunny

DAP : 127

Rhizoplane soil ≠ phyllo- and rhizodeposition

Rhizoplane soil surrounding a plant root where the biology and chemistry of the soil are influenced by the root.

Phyllo- and rhizodeposition C (bulk soil) can be operationally defined as the C lost by the living plant via roots, and includes both root exudates and fine dead root parts such as root hairs. (Engedal et al., 2023).

Bárcena et al., under preparation

Soil fractions

POM > 53 µm

MAOM < 53 µm

Bárcena et al., under preparation

Comparing approaches

CC	Cdfcc in soil (%)	fcover (%)
IR	8,4	2,4
OR	7,7	2,7
PH	11,3	2,6
SV	5,6	3,3

Tracer mass balance

$$\boxed{\mathrm{Cdfcc}\ (\%) = \left({}^{13}\mathrm{C}_{\mathrm{soil}}/{}^{13}\mathrm{C}_{\mathrm{total}}\right) \times 100}$$

Two-pool model/mixing model

$$f1 = \frac{\delta soil\ mixture - \delta soil\ control}{\delta cover\ crop - \delta soil\ control}$$

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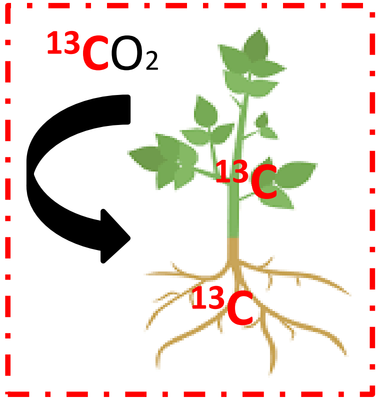
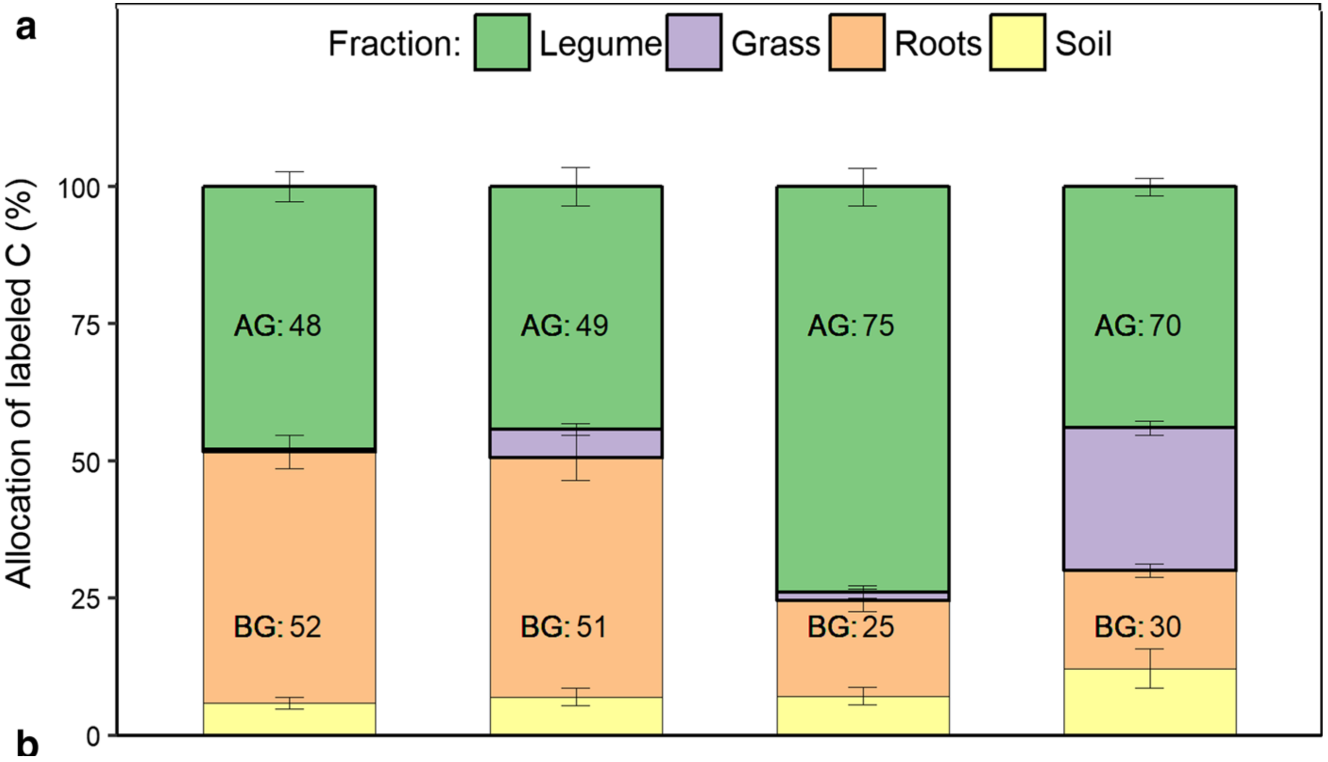
How much ^{13}C is allocated in the above- and belowground of each cover crop?

2021



September 2021



De Notaris, et al. Nutr Cycl Agroecosyst (2020) 116:1–18

Allocation of labbeled C in different pools, calculated as percentages of the total amount of labeled C:

Labeled C allocation pool (%) = (^{13}C pool / ^{13}C total) *100

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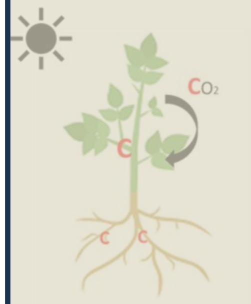

2021

sequestering CO_2 from the atmosphere

Growing CC

1st Sampling (plant&soil)

2021

Incorporation
Roots vs Shoots

2022

2023

C persistence into soil

2nd soil sampling

3rd soil sampling

summer/spring | autumn | autumn | autumn | autumn

Bárcena et al., under preparation

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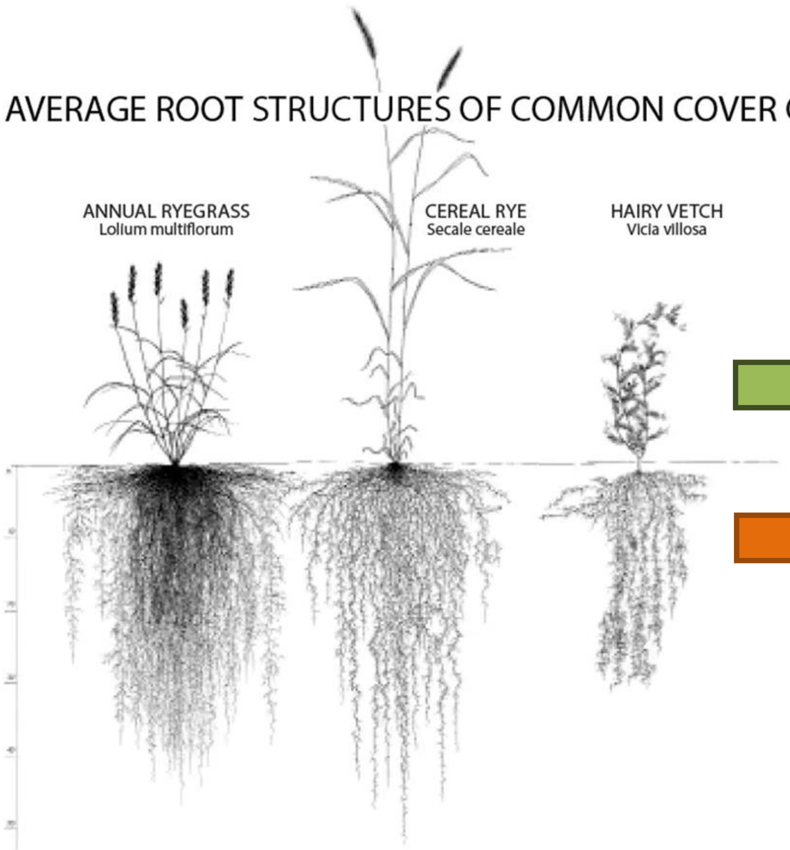
C persistence in 2022, 2023



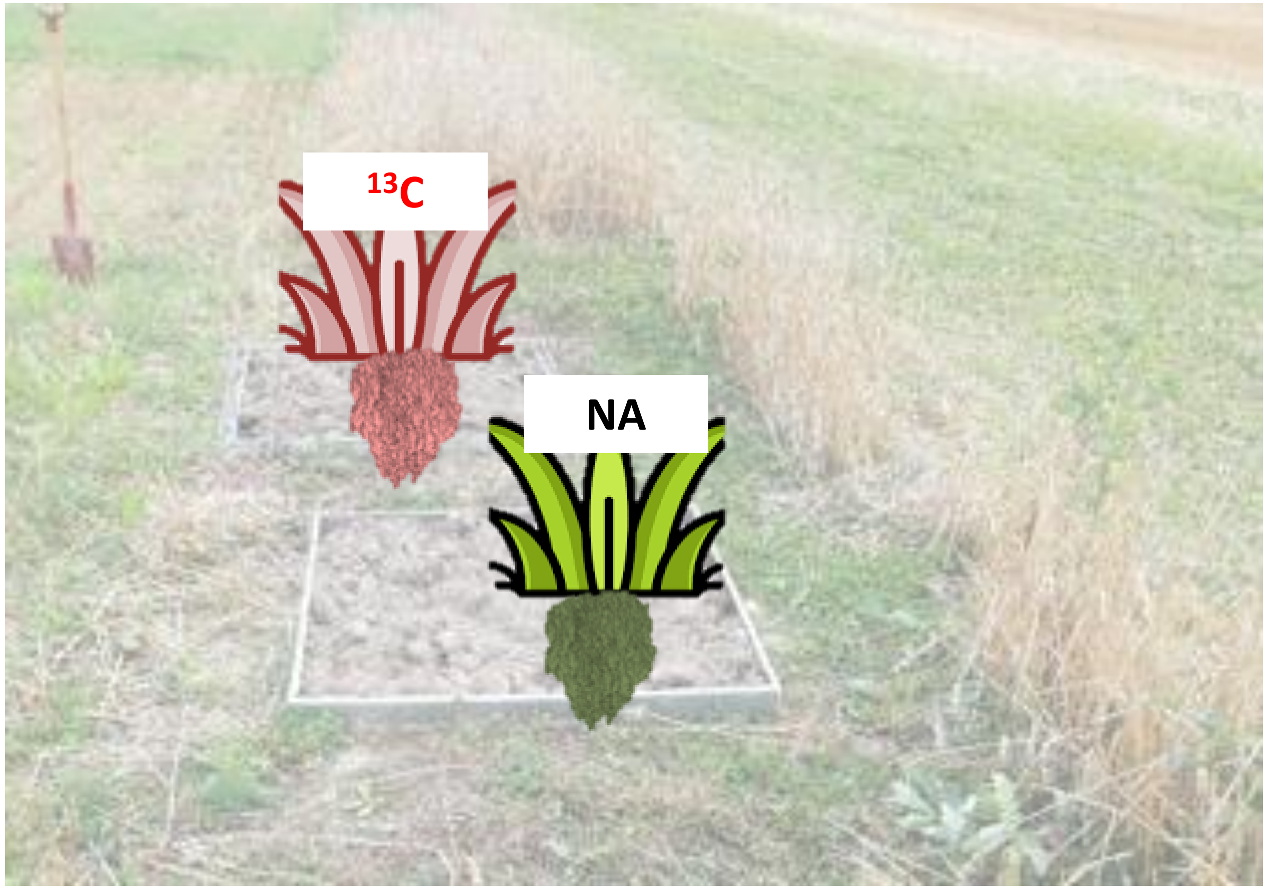
https://www.deere.com/en/publications/the-furrow/2021/sept-fall-2021/the-root-project/

Aboveground input

Belowground input

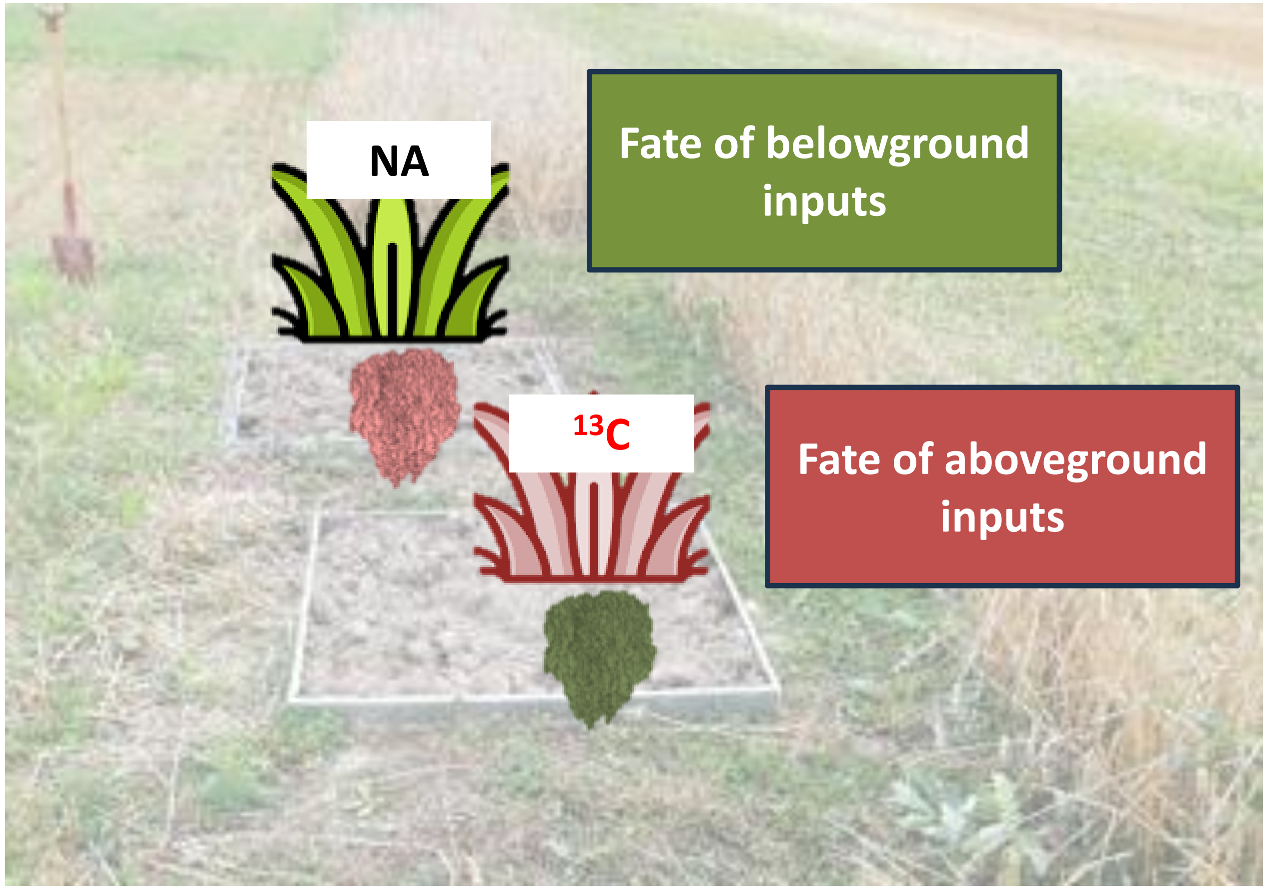
Bárcena et al., under preparation

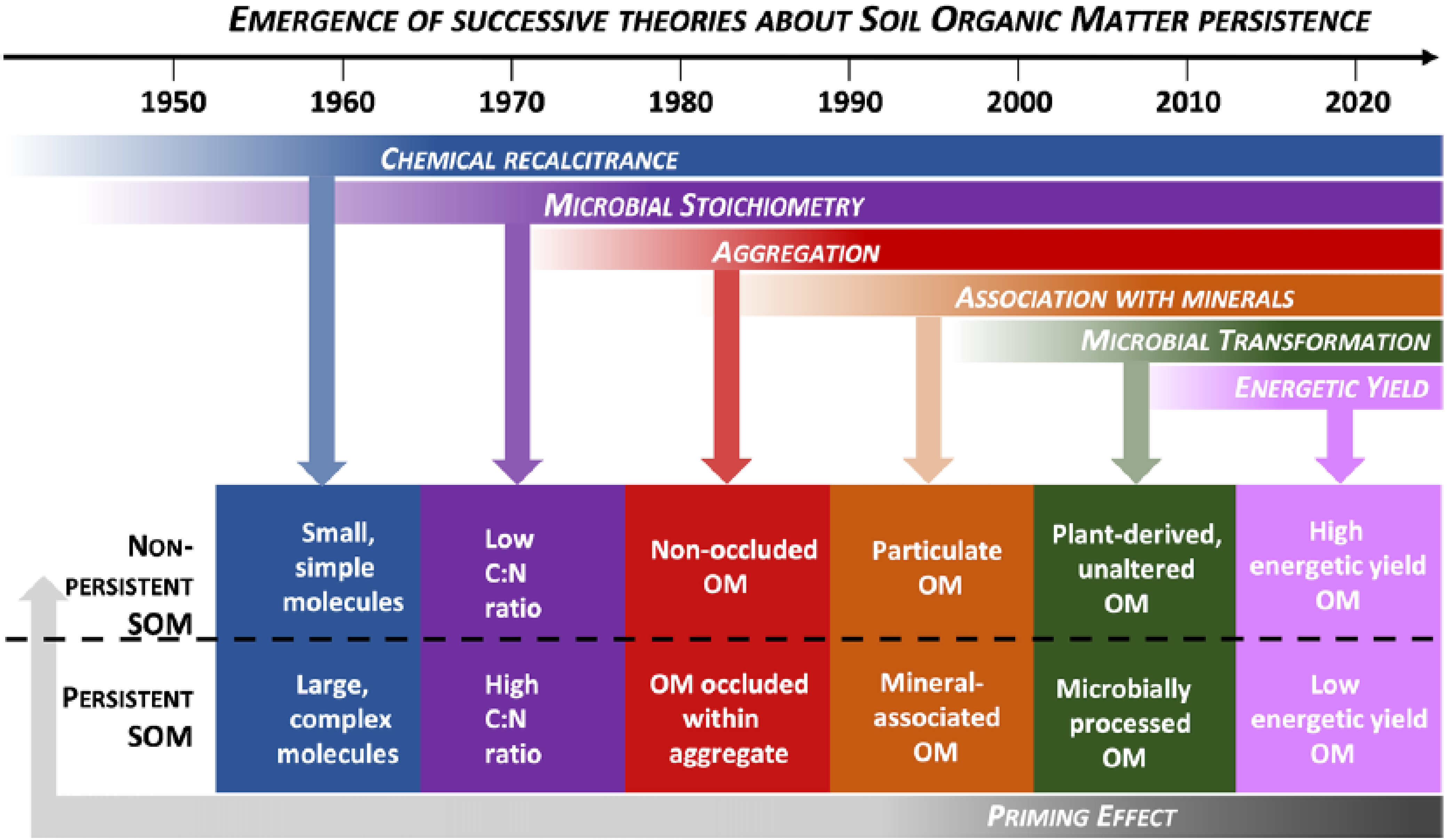
Reciprocal experiment



Reciprocal experiment

Reciprocal experiment





Derrien et al., 2023

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Discussion points

- How does uneven labeling uniformity affect the accuracy of carbon estimations in isotope-tracing studies?
- In carbon tracing experiments, when is it appropriate to use the tracer mass approach versus the two-pool model?
- What are the key belowground carbon pools, and how do they contribute to the soil carbon cycle?
- In the theories of soil organic matter persistence, where are we?