



Norwegian Centre for Organic Agriculture

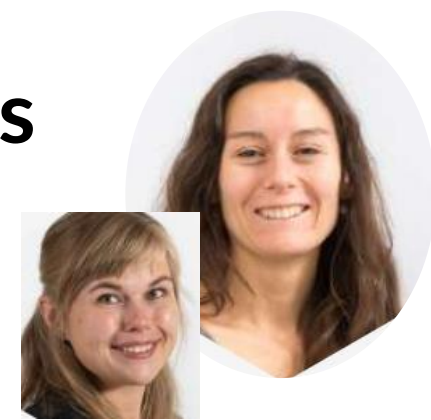
in situ ^{13}C pulse labelling and tracing

Methodological approach and challenges for application in cover crop research

Tatiana Rittl

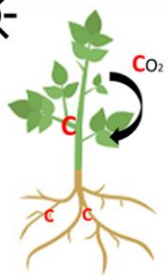
October 2024

The fate of above and belowground CC carbon inputs in soil



Four different cover crops revelant for cereals production in Norway

Feature	Italian Ryegrass (<i>Lolium multiflorum</i>)	Oilseed Radish (<i>Raphanus sativus</i>)	Summer Vetch (<i>Vicia sativa</i>)	Phacelia (<i>Pha. tanacetifolia</i>)
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



2021

sequestering CO₂ from the atmosphere

Growing CC



1st sampling
(plant&soil)



2021



Incorporation CC



2022

C persistence into soil

2nd soil sampling



2023

3rd soil sampling



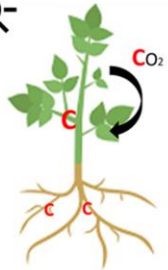
summer/spring

autumn

autumn

autumn

autumn



2021

sequestering CO₂ from the atmosphere

Growing CC



1st sampling
(plant&soil)



summer/spring

autumn



2022

2023

C persistence into soil

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2nd soil sampling



3rd soil sampling



autumn

autumn

autumn



Cover crop growing conditions

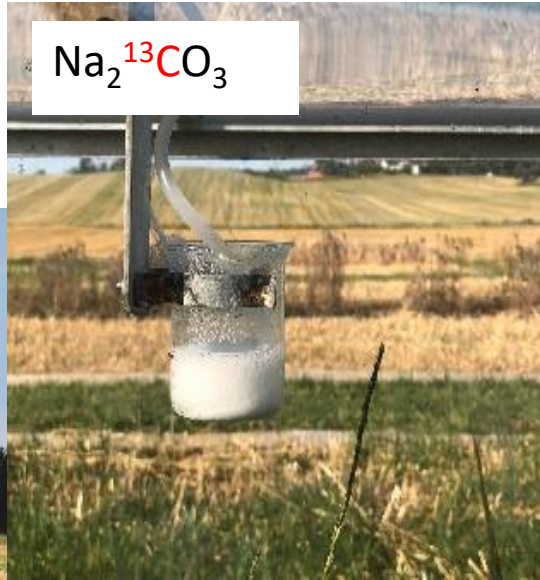
Trace belowground C originating from each individual species



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

In situ ^{13}C pulse-labelling

June – September



Summer vetch
5 pulse labelling



Phaselia
5 pulse labelling



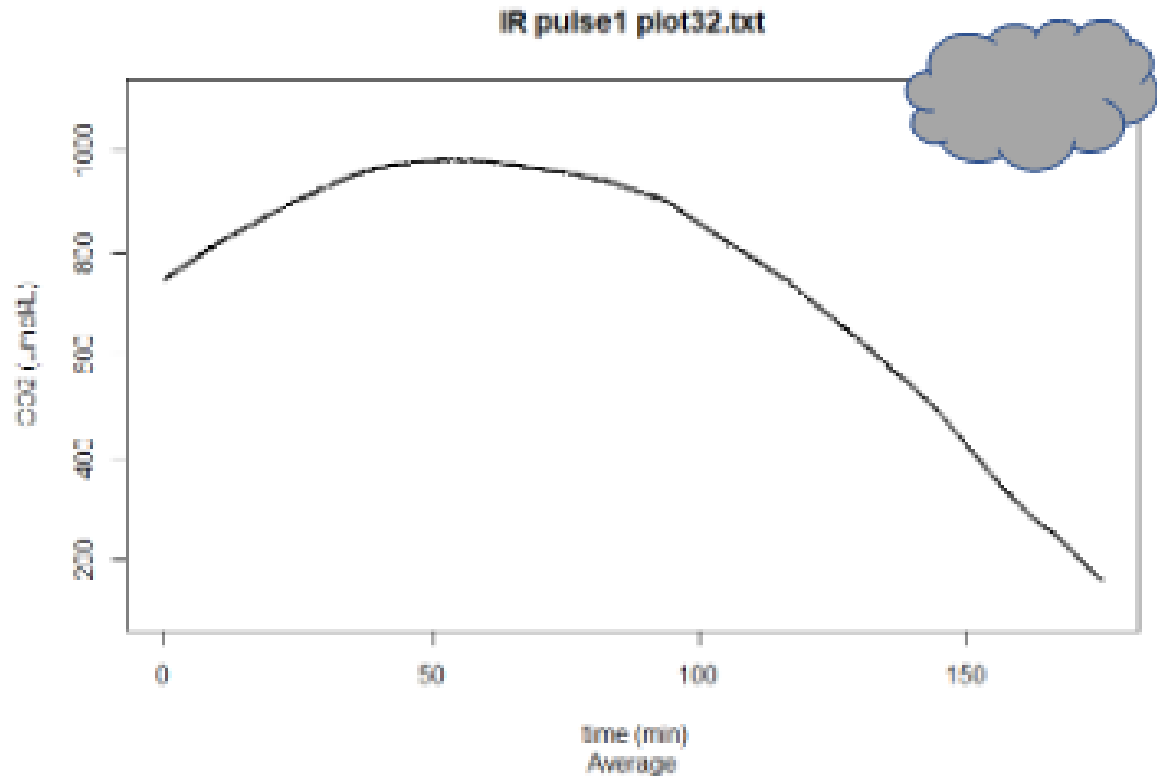
I. Ryegrass
6 pulse labelling



O. radish
5 pulse labelling



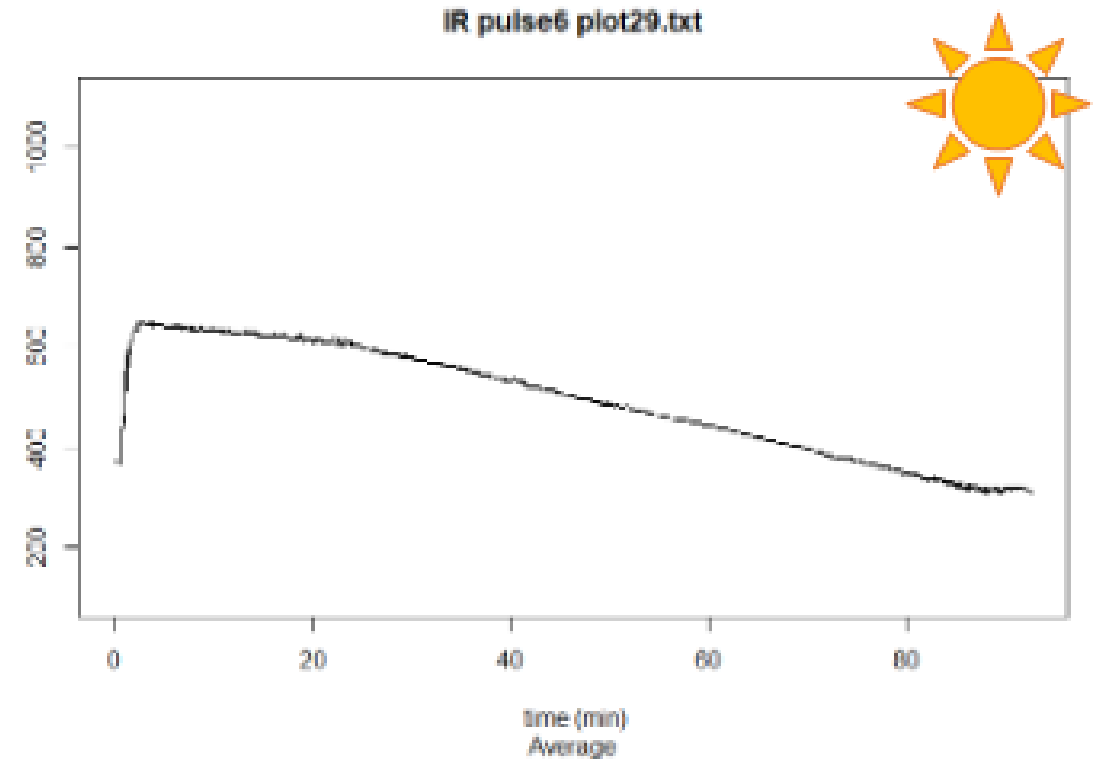
CO₂ uptake monitored with an Infra-Red Gas Analyzer



Date, time : 2021-06-29, 8:5:26

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).

Soil fractions

POM > 53 μm



MAOM < 53 μm



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

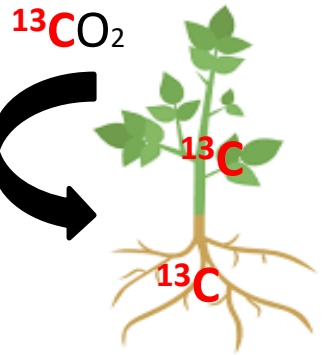
Tracer mass balance

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

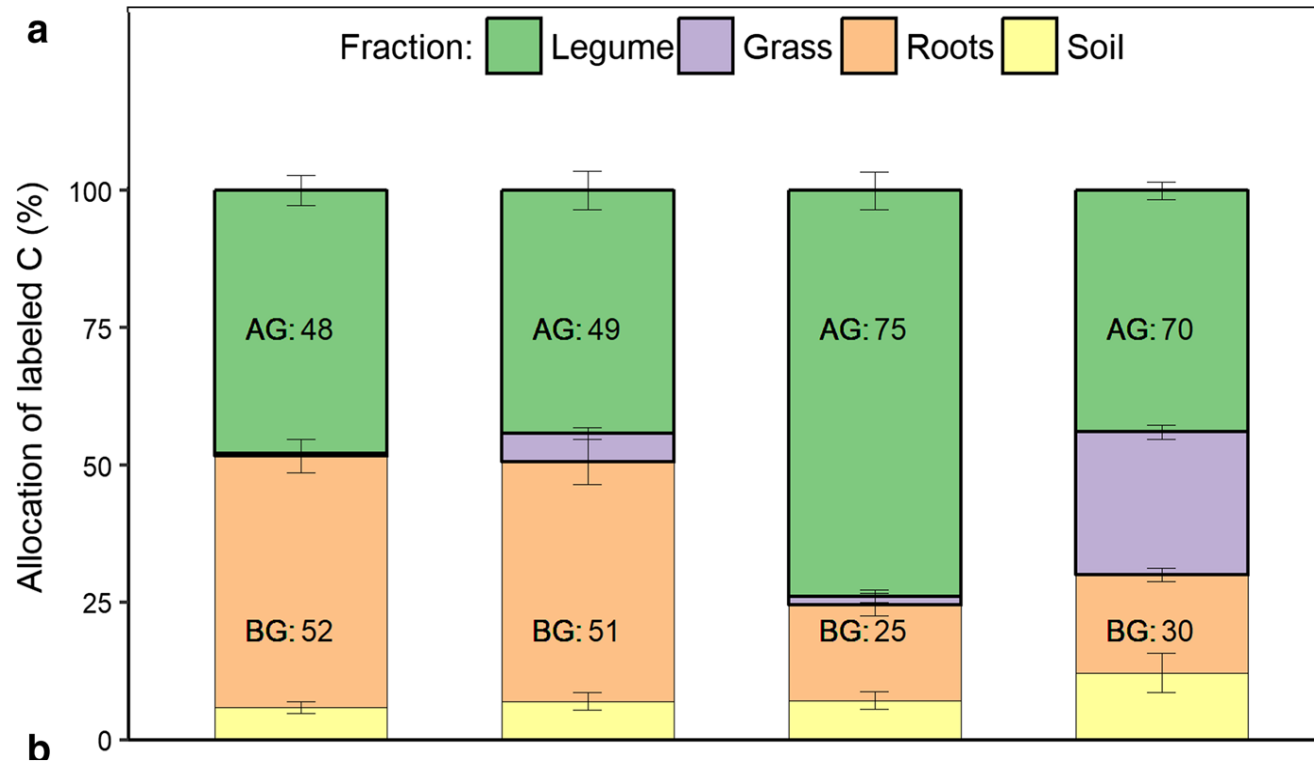
Two-pool model/mixing model

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

☀ 2021



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



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

Labeled C allocation pool (%)

$$= \left(\frac{^{13}\text{C pool}}{^{13}\text{C total}} \right) * 100$$

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



Incorporation
Roots vs Shoots



2022

C persistence into soil

2nd soil sampling



2023

3rd soil sampling



autumn

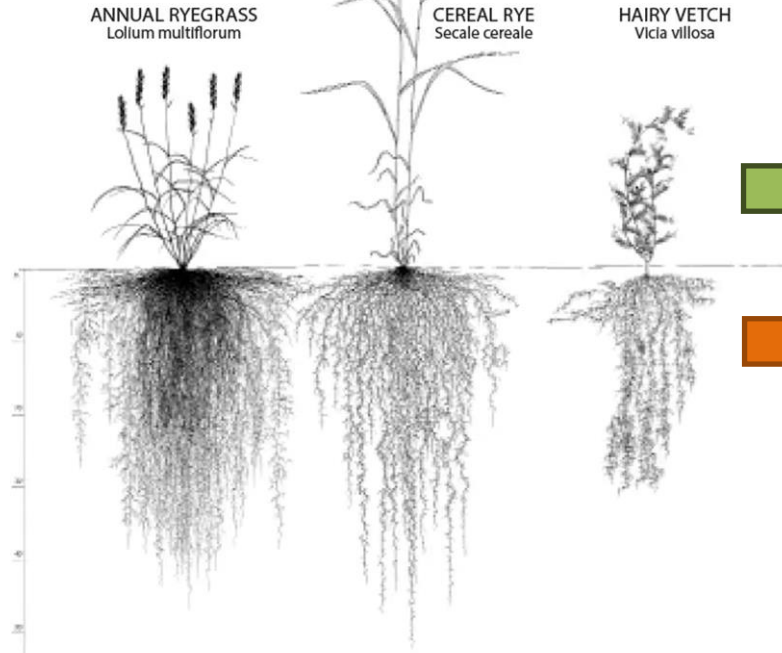
autumn

autumn

C persistence in 2022, 2023



AVERAGE ROOT STRUCTURES OF COMMON COVER CROPS



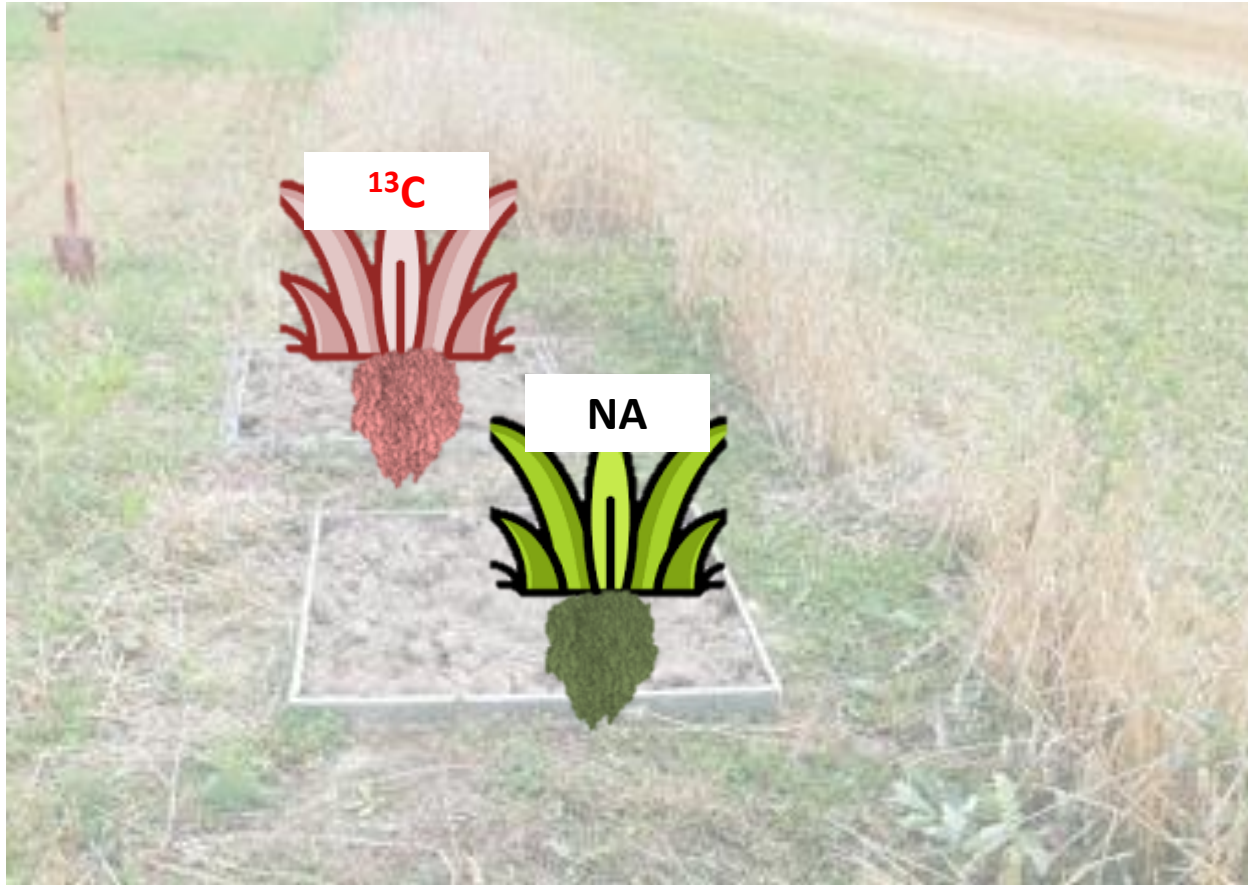
Aboveground input



Belowground input

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

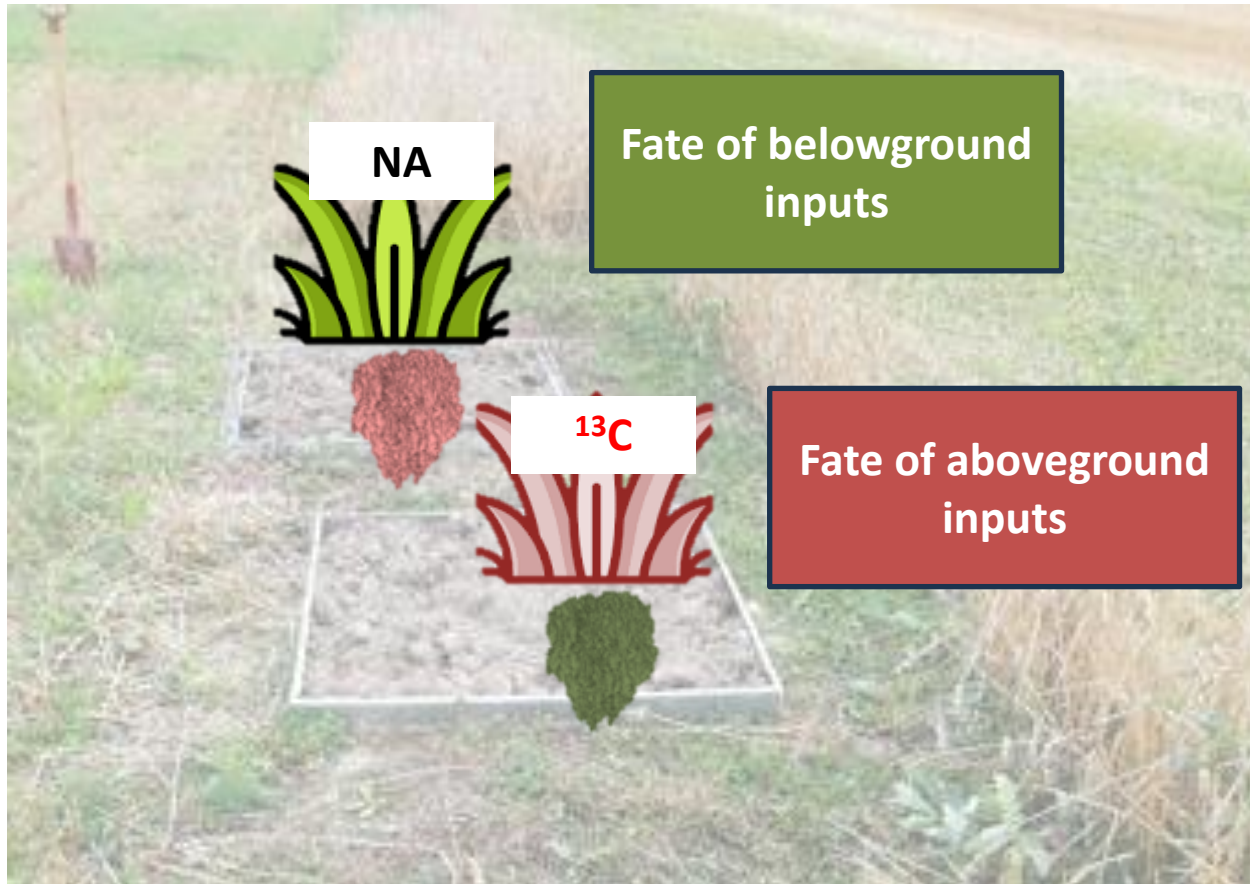
Reciprocal experiment



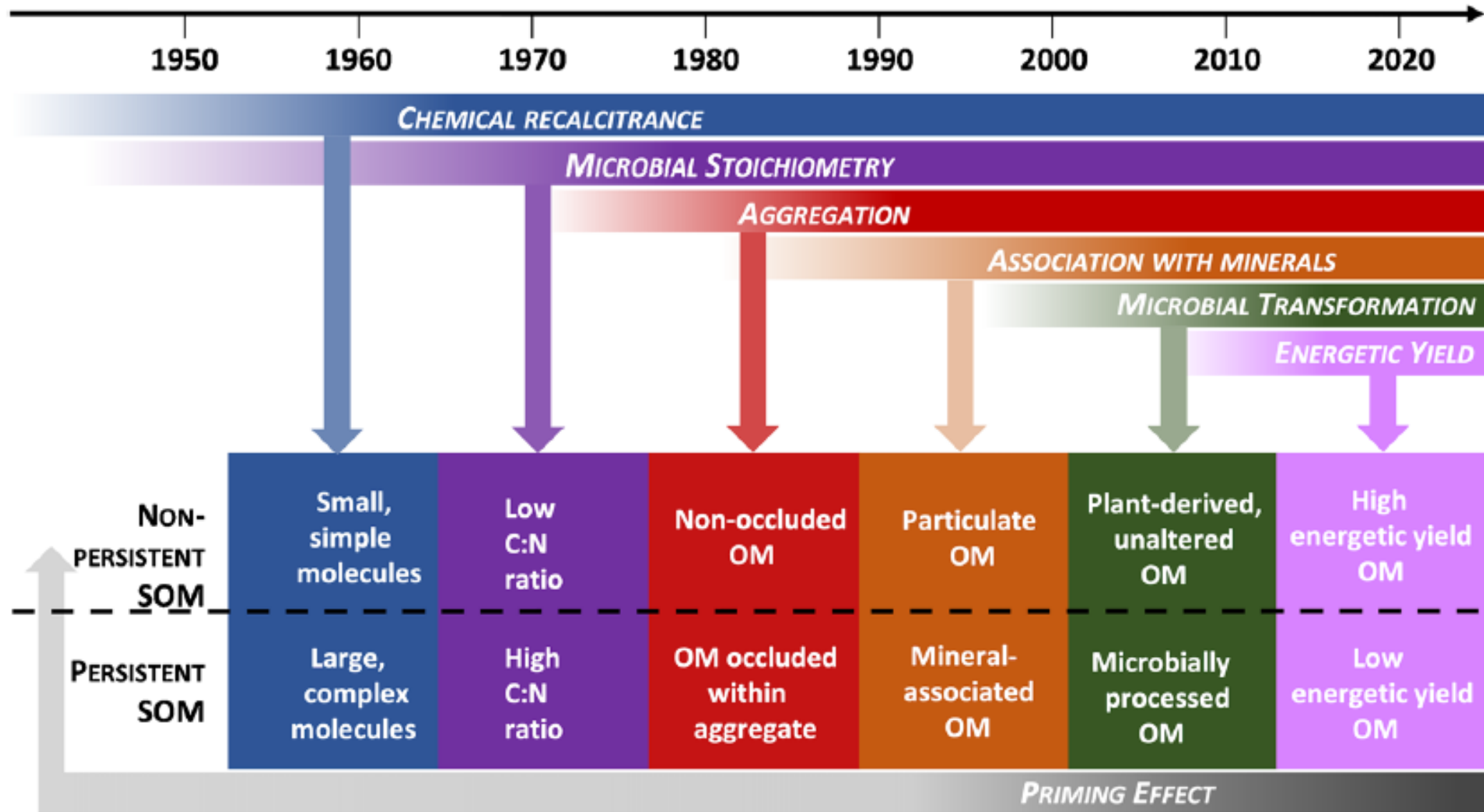
Reciprocal experiment



Reciprocal experiment



EMERGENCE OF SUCCESSIVE THEORIES ABOUT SOIL ORGANIC MATTER PERSISTENCE



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?