Assemblée générale du SOERE PRO

Mardi 24 novembre 2015, INRA de Colmar

SOERE-PRO

The fate of C and P in long-term compost or FYM amended soils: a comparison between French and Belgian experiments

Erik Smolders, Tim De Clercq, Thijs Vanden Nest, and Roel Merckx

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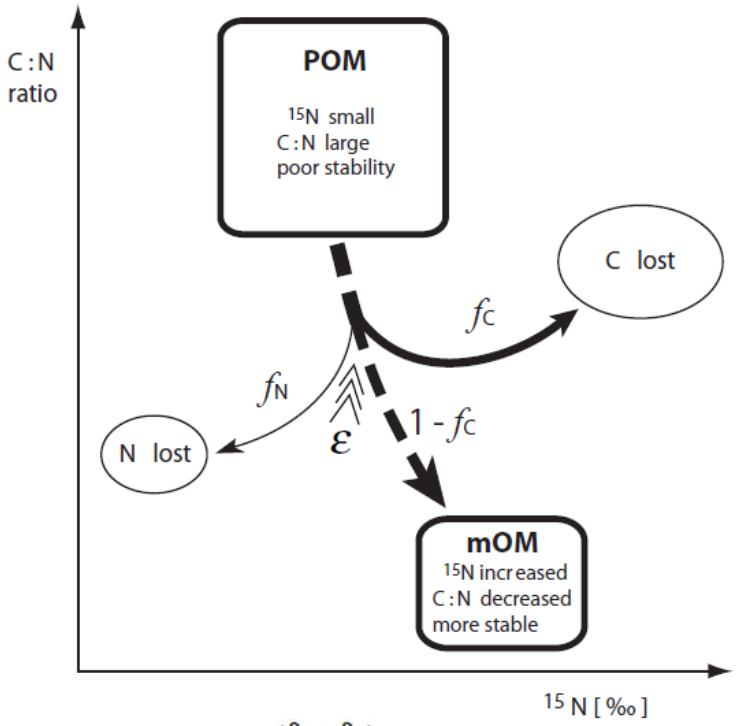
Part 1: carbon

VFG Compost amended soils as a topic to search for new SOC Stability assays using Stable Isotope Techniques



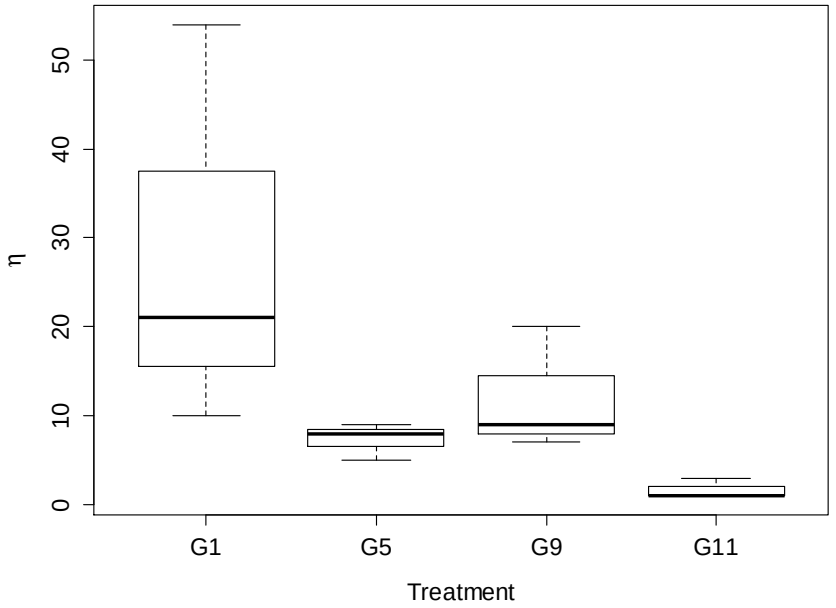
$$f_N = 1 - e^{\left(\frac{\delta_m - \delta_p}{\varepsilon}\right)}$$

$$f_C = f_N + (1 - f_N) \cdot \left(1 - \left(\frac{r_m}{r_p}\right)\right)$$

$$n = \frac{C_m}{C_p \cdot (1 - f_C)}$$

Conen *et al.* 2008

η = age mOM / age POM

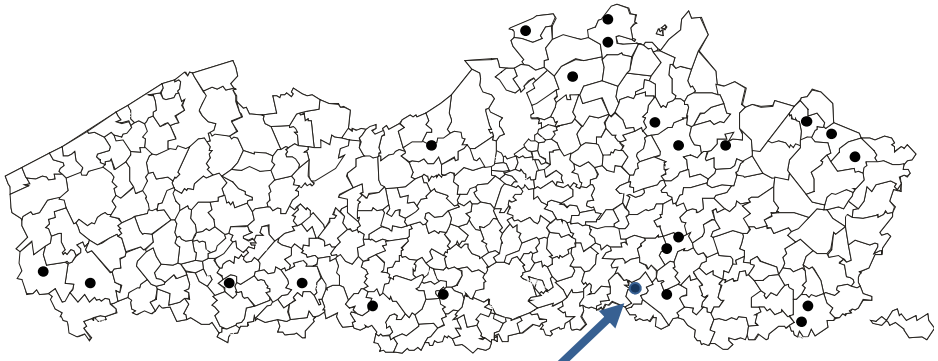


Current work:

- Adapting model for use on agricultural soils
- Improving model accuracy by incorporating additional parameters e.g. $\delta^{13}C$

VFG Compost Experiment

- Set up in 1997
- Crop rotation: beet, wheat and potatoes
- Start conditions:
  - %C = 0,9
  - pH-KCl = 6,9
  - Loamy soil

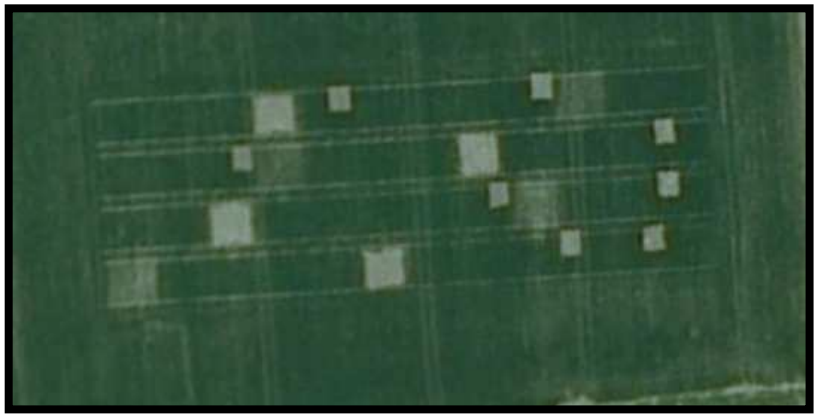


Boutersem, Belgium

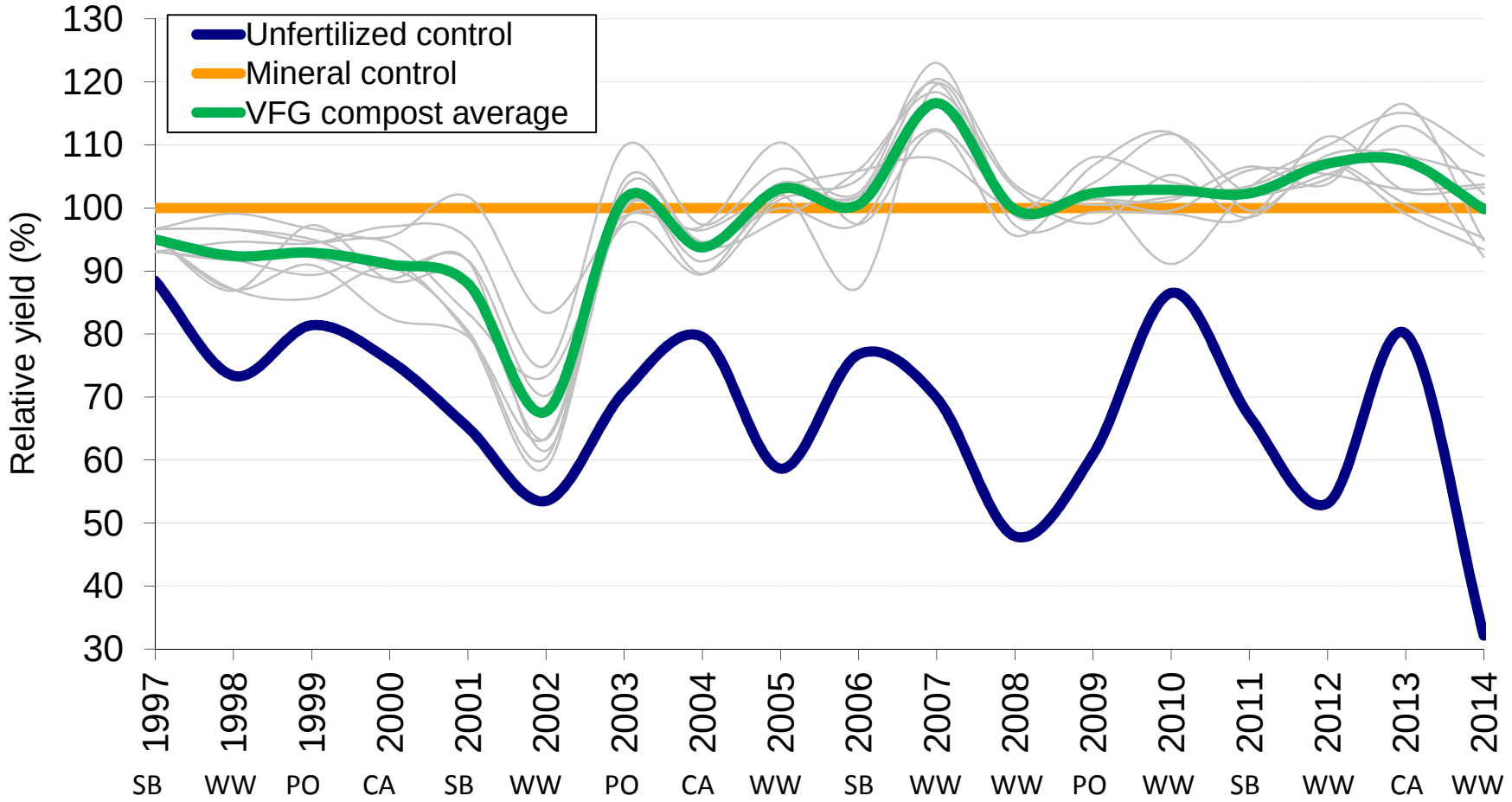
Experimental Layout

blok 4	8 4	4 8	9 12	12 16	11 14 20	3 24	7 28	2 32	5 13 36	1 40	10 44	6 48
blok 3	3 3	7 7	11 14 11	1 15	6 19	10 23	8 27	12 31	2 35	9 39	4 43	5 13 47
blok 2	6 2	10 6	12 10	8 14	2 18	7 22	9 26	11 14 30	1 34	4 38	3 42	5 13 46
blok 1	1 1	2 5	3 9	9 13	6 17	12 21	4 25	10 29	7 33	5 13 37	11 14 41	8 45

- 14 treatments
  - 3 levels of VFG compost (15, 30 and 45 t/ha)
  - 3 application frequencies (every 1, 2 or 3 years)
  - Mineral fertilized control
  - Unfertilized control
  - Bare control



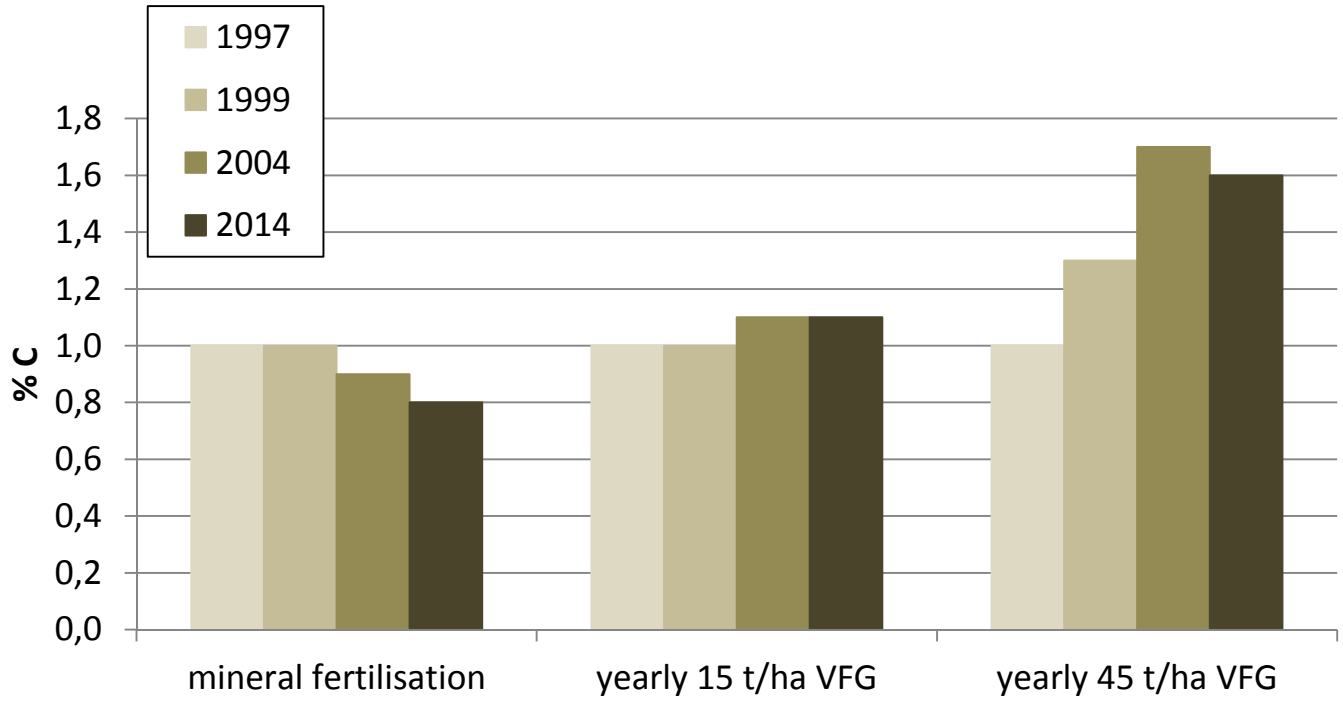
Relative Yield after 18 Years



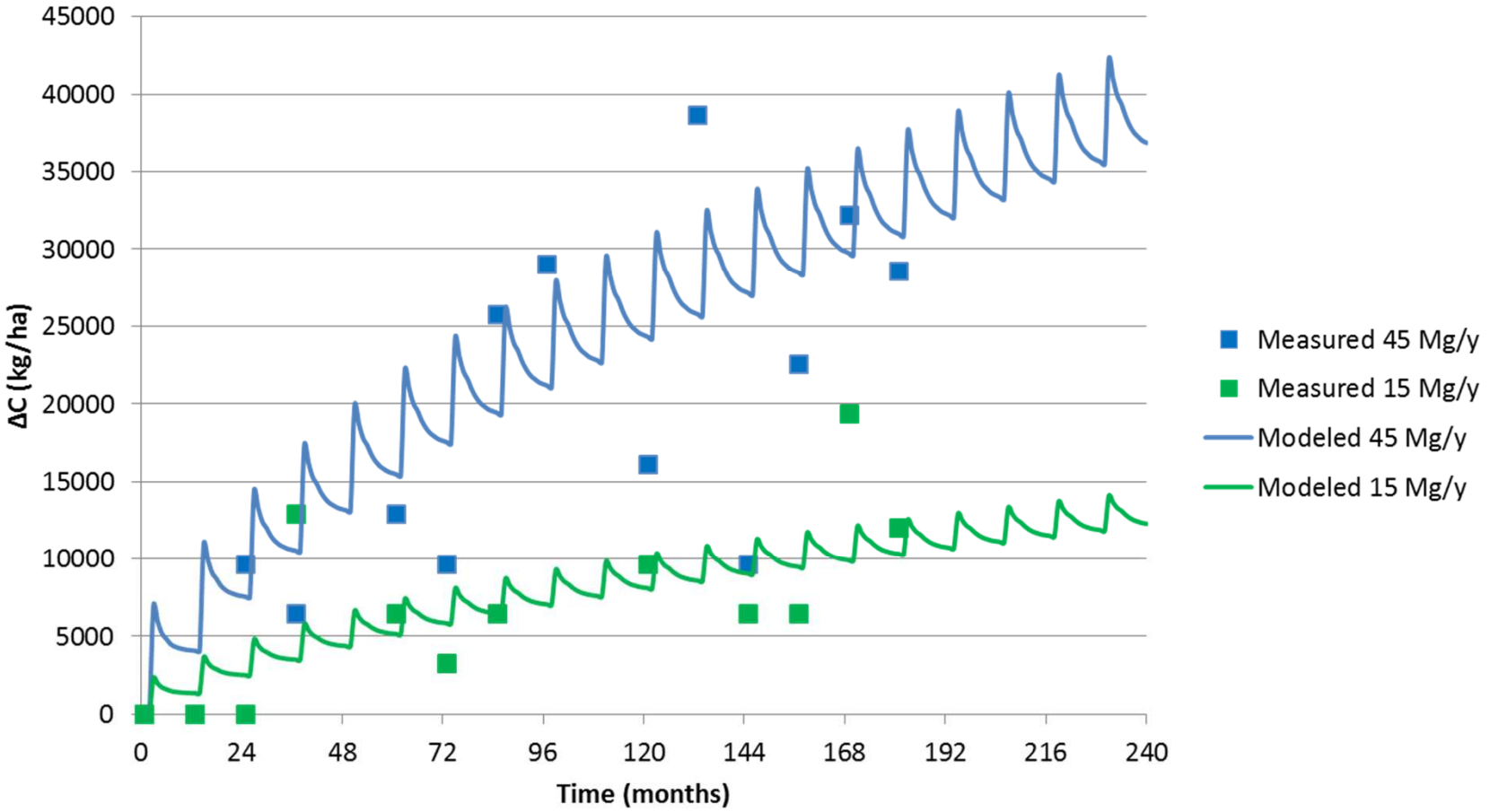
SB: sugar beet WW: winter wheat

CA: carrots PO: potatoes

Soil Organic Carbon after 18 years



Roth-C Modeling of SOC Increase with Compost Amendment



Fitting of difference in SOC stock (ΔC) 45Mg compost ha^{-1} $year^{-1}$ and 15Mg compost ha^{-1} $year^{-1}$ compared to mineral fertilized control.

Comparison of Partitioning Coefficients with French field trials

Experiment	ƒ DPM	ƒ RPM	ƒ HUM	CV(RMSE)	Temperate climate soil C increase (Mg C ha^{-1} y^{-1}) at 2 ton C input/ha/2 y
VFG compost Boutersem	0.40	0.50	0.10	52.4 %	0.36
Municipal solid waste compost, Qualiagro	0.62	0.38	0	13.9 %	0.23
Biowaste compost Qualiagro	0	0.80	0.20	17.0 %	0.50
Green waste and sludge compost Qualiagro	0.15	0.65	0.20	13.3 %	0.46
Enriched coffee cake compost SERAIL	0.40	0.60	0	61.5 %	0.29
Enriched bark compost SERAIL	0.09	0.82	0.09	41.2 %	0.42

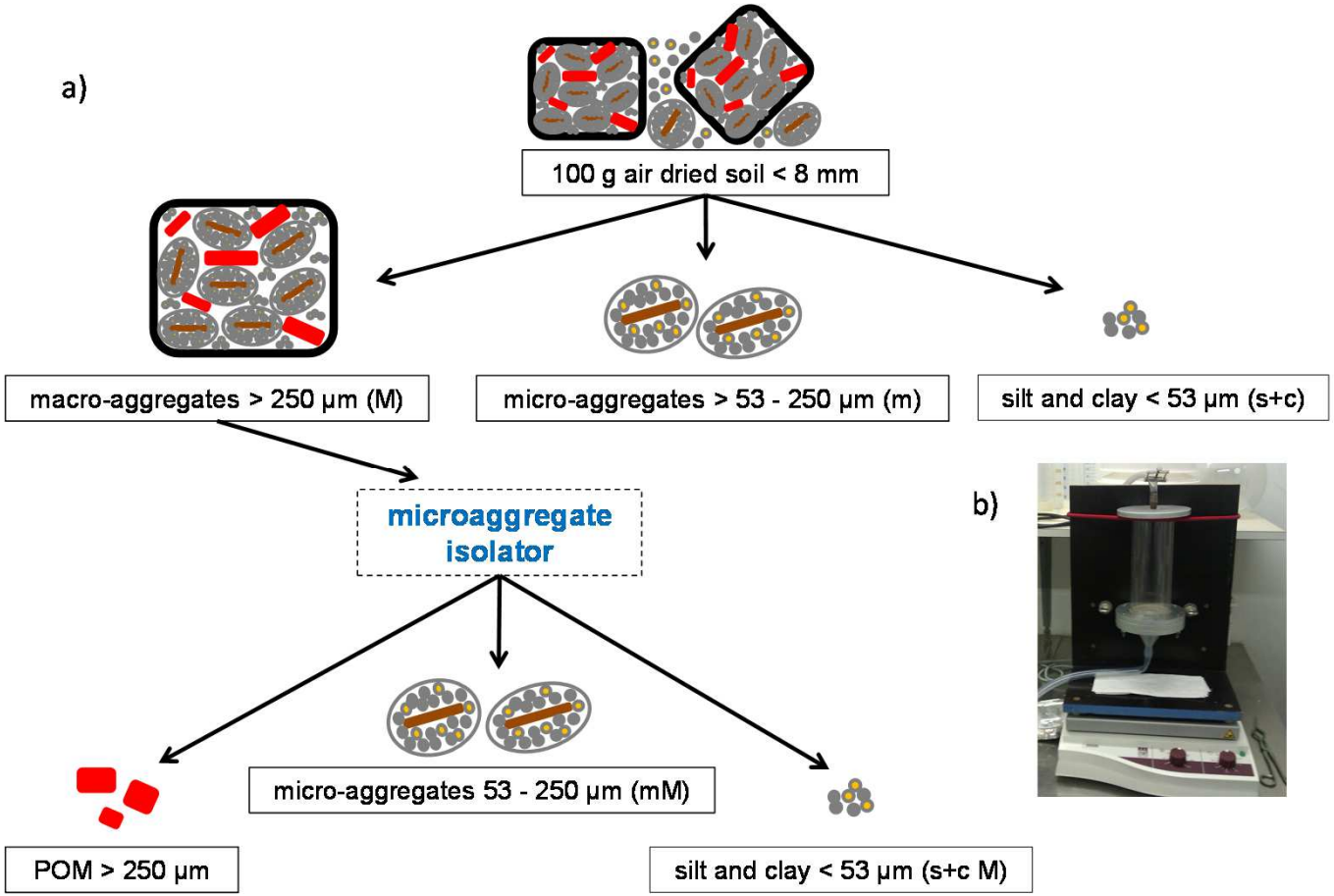
DPM: mean residence time 1.2 month

RPM: mean residence time 3.3 y

HUM: mean residence time 50 y

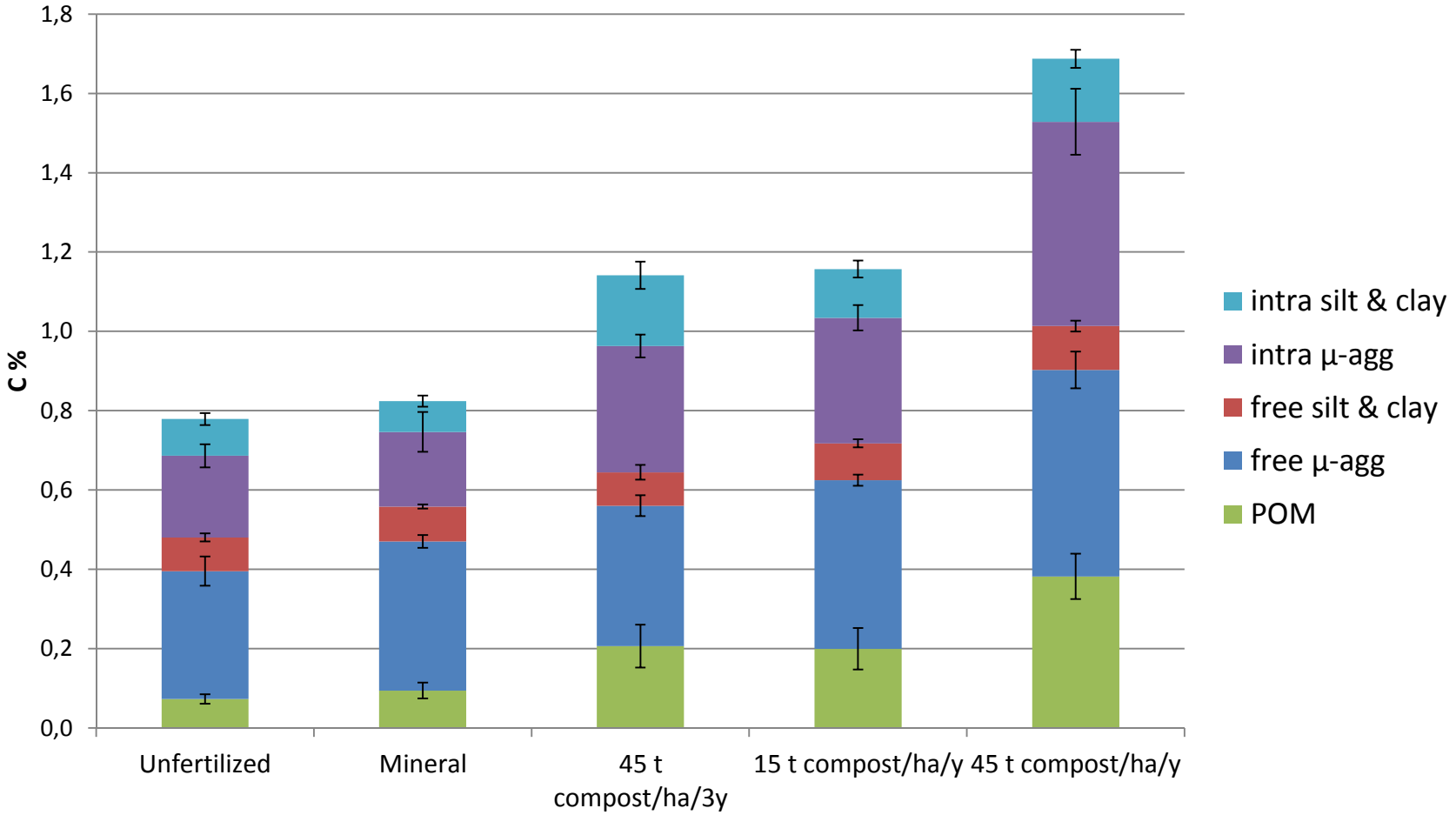
Data Peltre et al. 2012

Isolation of Main SOC Fractions

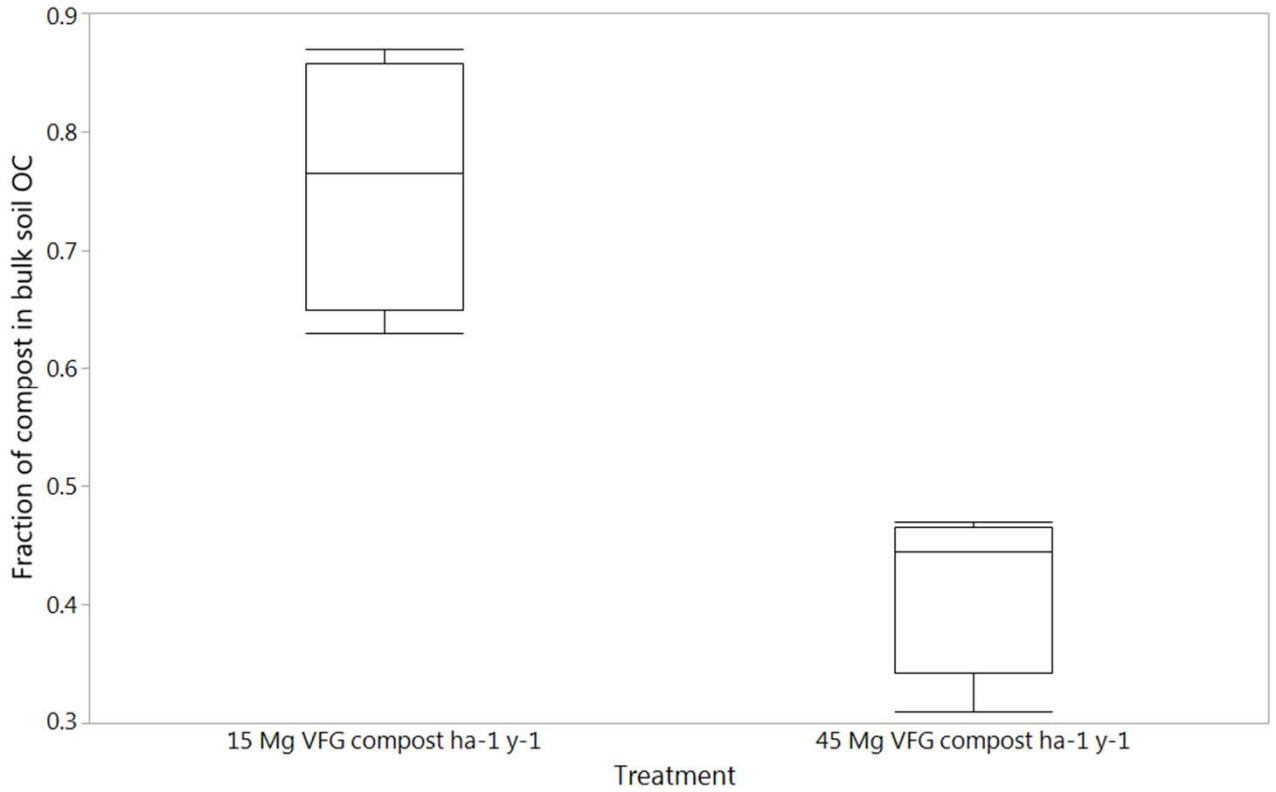


Based on Six *et al.* 2002

SOC Distribution among Fractions



Compost Derived SOC fraction decreases with increasing compost application rate after 18 years



- $\delta^{13}C$ mineral control: -26.5 ‰
- $\delta^{13}C$ VFG compost: -28.6 ‰

Part 2: phosphorus

Effects of organic amendments on P leaching

Field experiment set-up

M05.01, BE

- Silt loam
- °2005
- Red cabbage, fodder beet, maize, potato, winter wheat…
- ~3 ton C/ha.year
- Selected NPK addition for optimal supply

Treatments

- CMC-compost (2)
- VFG compost
- Farmyard manure
- Cattle slurry
- Mineral fertilizers
- No fertilizers
- Fallow

QUALIAGRO, FR

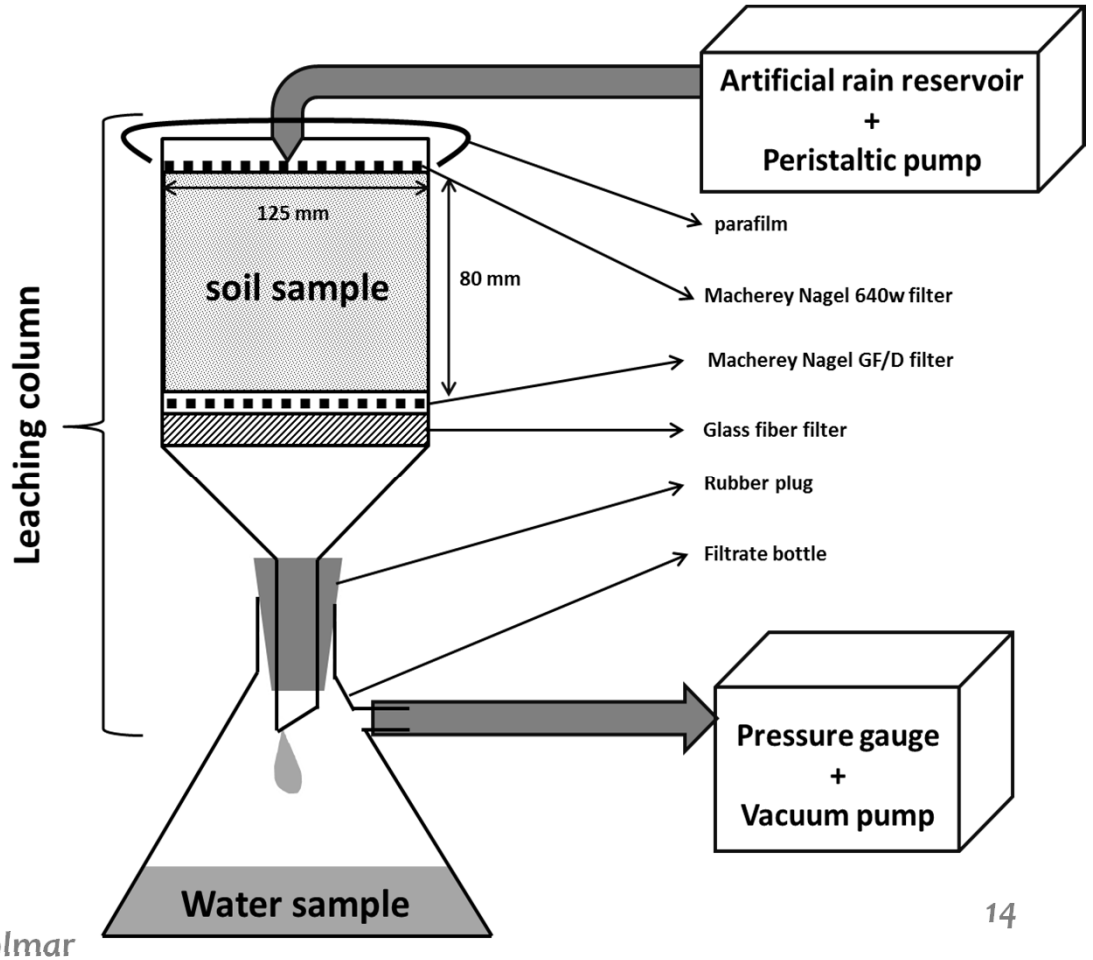
- Silt loam
- °1998
- Winter wheat-maize

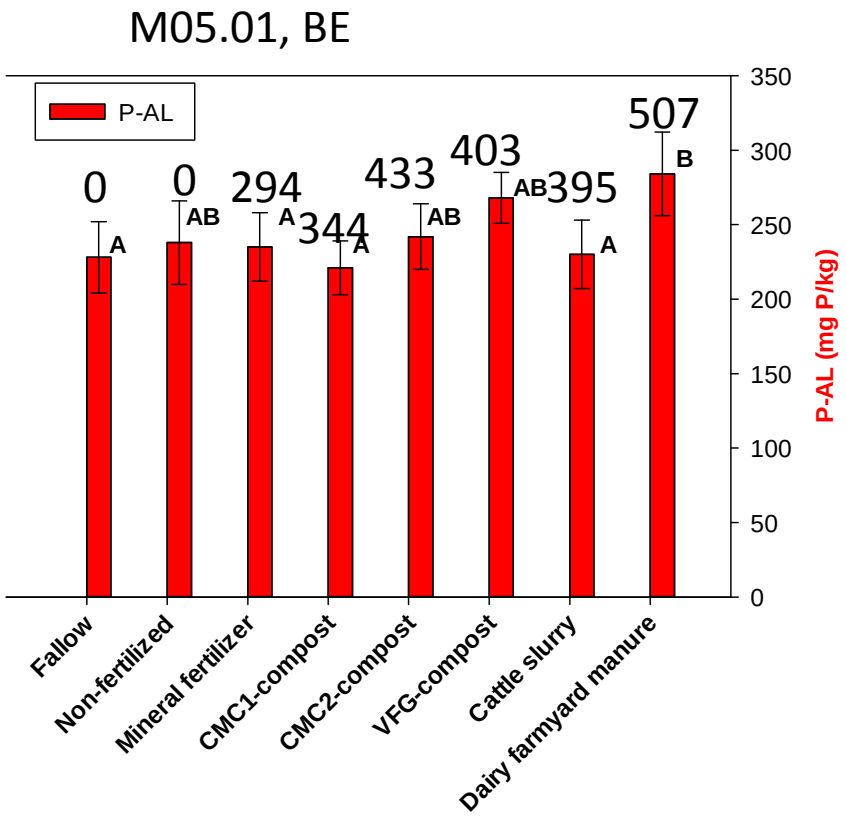
- 4 ton C/ha.2year
- No PK correction

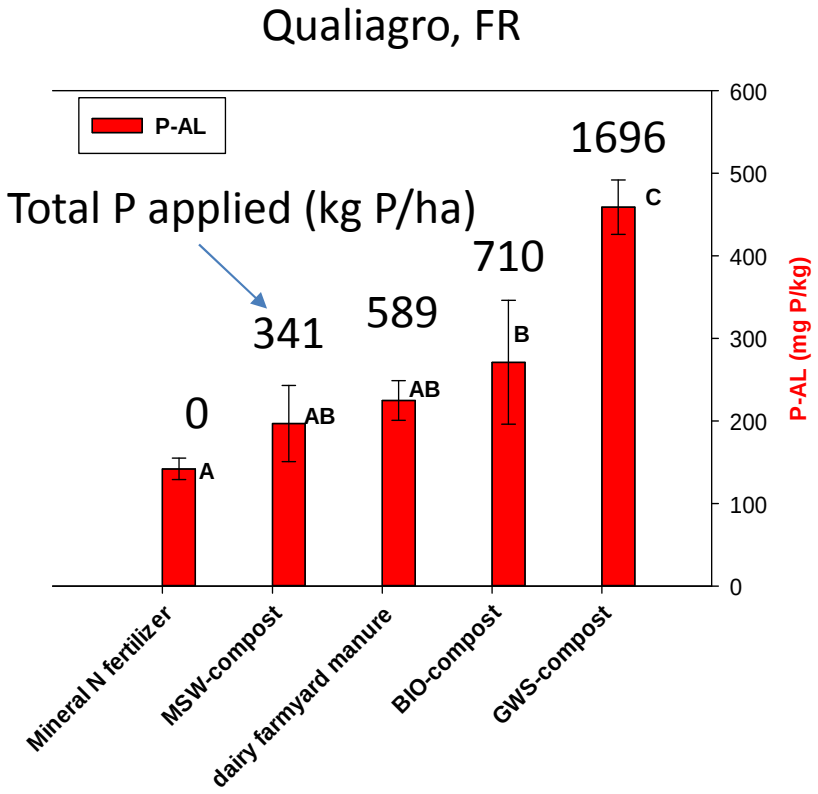
Treatments

- composts (2)
- GWS-compost
- Farmyard manure
- N fertilizer

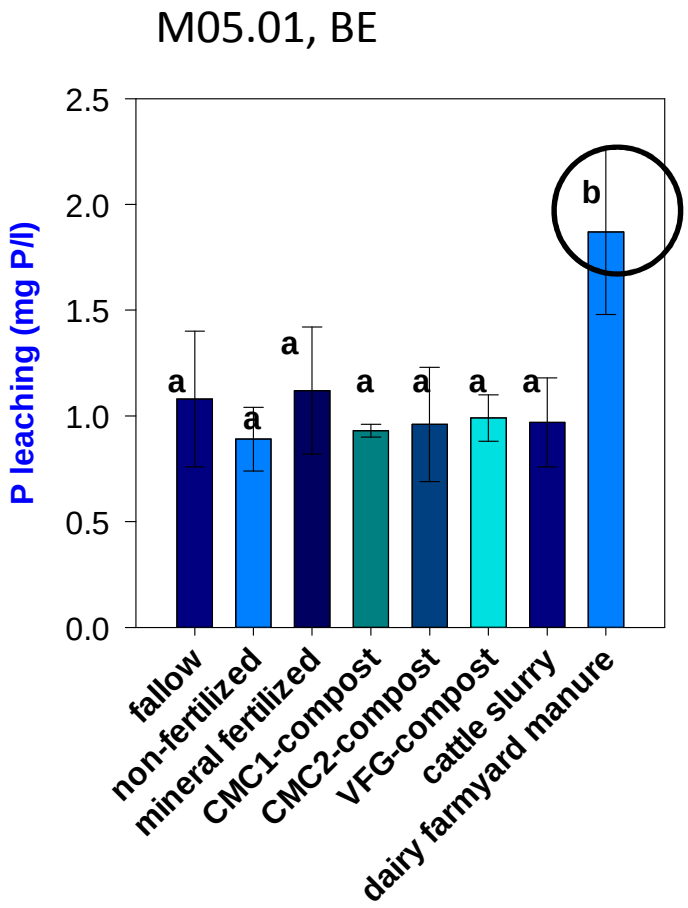
P leaching equipment

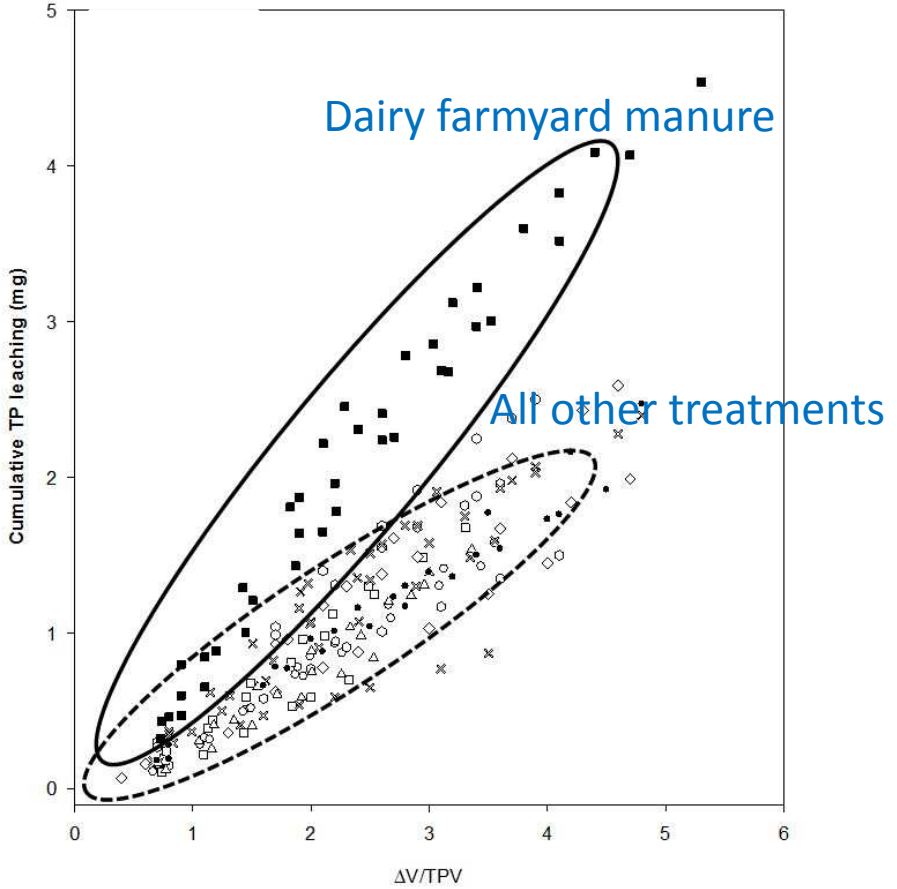






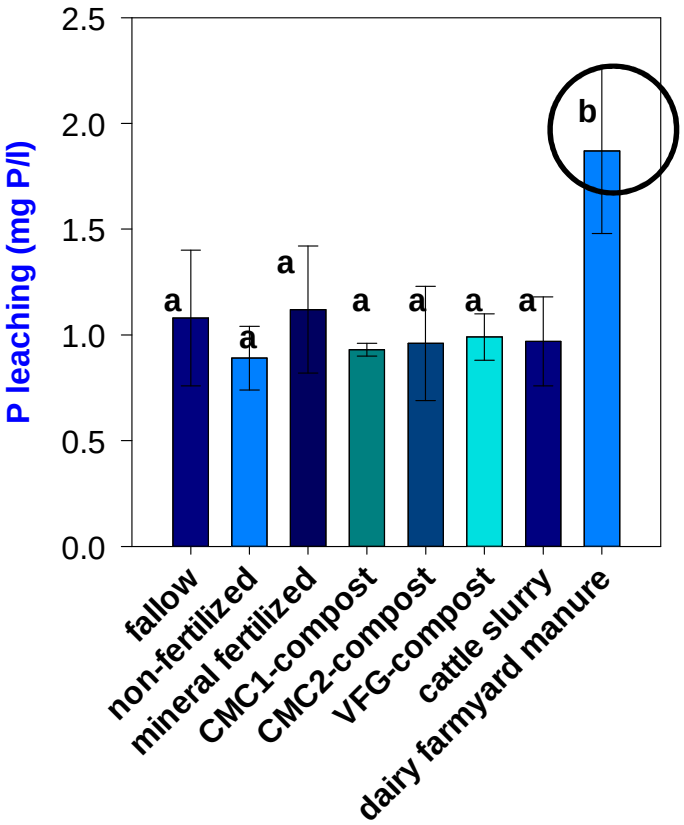
Soil P input and ammonium lactate extractable soil P (P-AL) for the amended soils

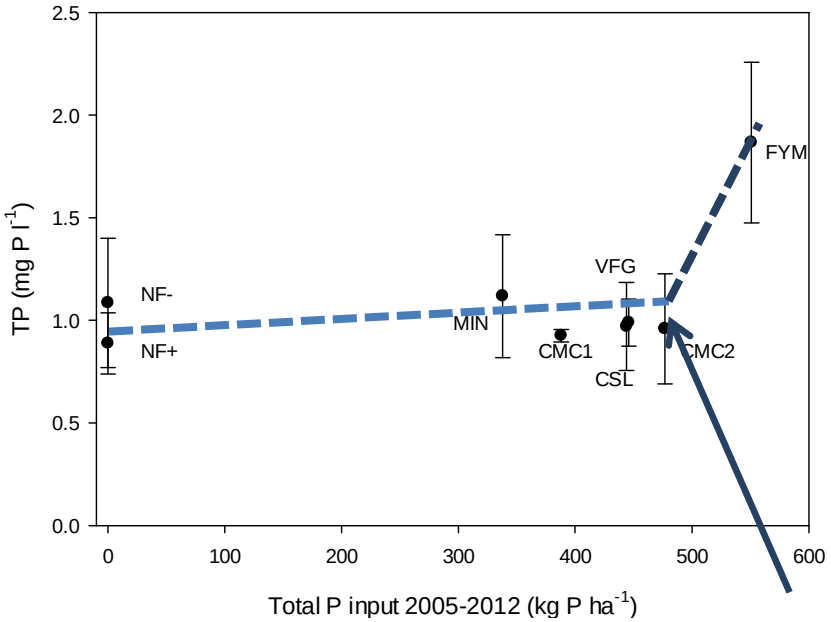




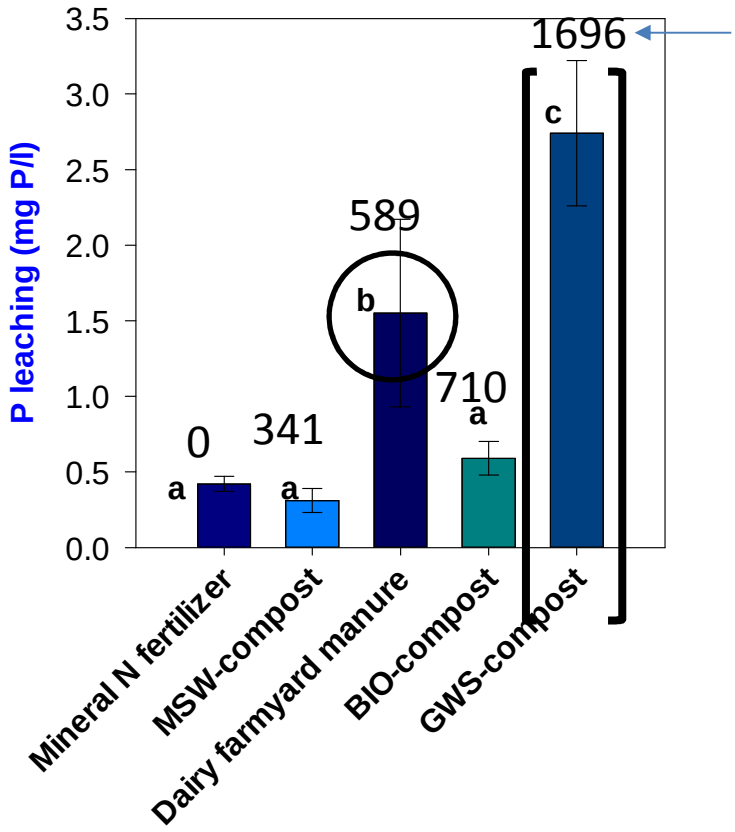
Highest concentration of P in leachates of FYM amended soils in Belgian trial

M05.01


P leaching (mg P/l)
2.5
2.0
1.5
1.0
0.5
0.0
a
a
a
a
a
a
a
b
fallow
non-fertilized
mineral fertilized
CMC1-compost
CMC2-compost
VFG-compost
cattle slurry
dairy farmyard manure


TP (mg P l-1)
2.5
2.0
1.5
1.0
0.5
0.0
0
100
200
300
400
500
600
Total P input 2005-2012 (kg P ha-1)
NF-
NF+
MIN
CMC1
VFG
CSL
CMC2
FYM

Qualiagro, FR

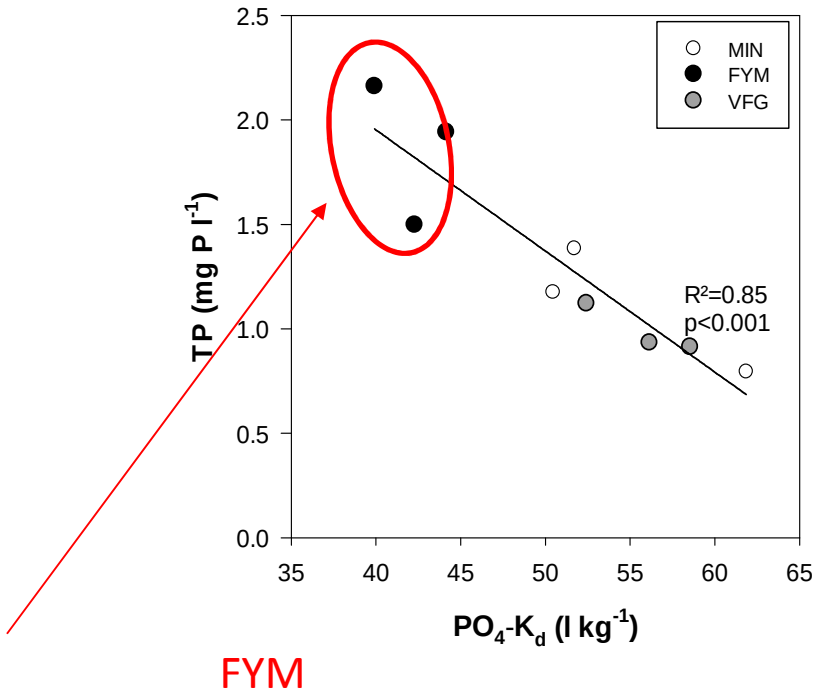


Total P input (kg P/ha)

Highest concentration of P per unit P input in leachates of FYM amended soils in French trial

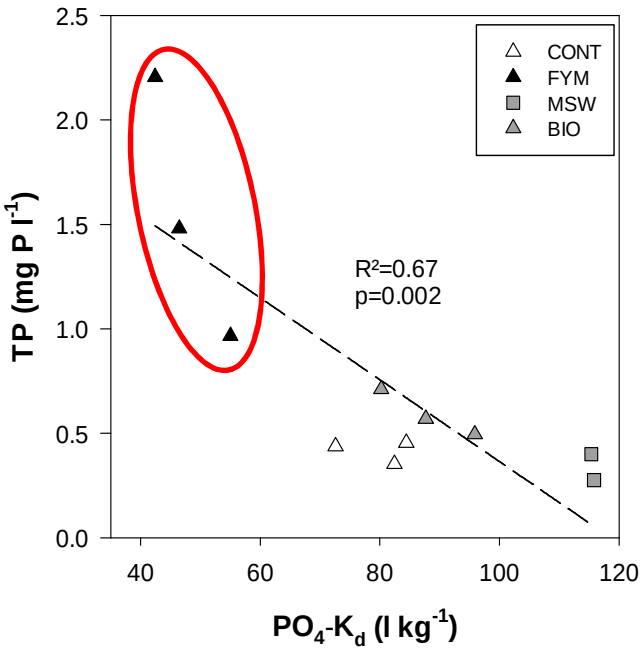
$^{33}PO_4$ adsorption studies reveal reduced sorption of PO_4 in FYM amended soils

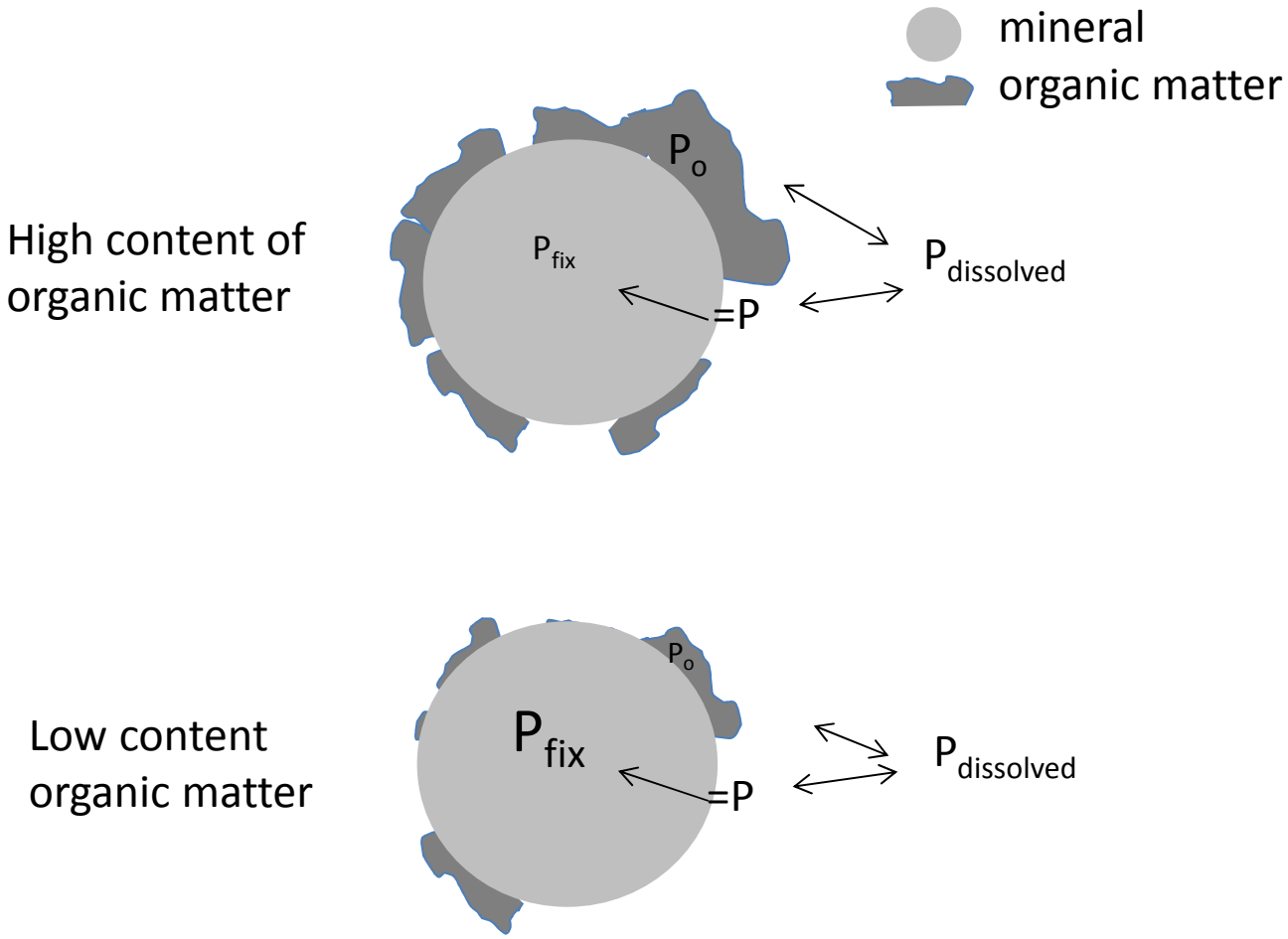
M05.01, BE



FYM

Qualiagro, FR




mineral
organic matter
High content of organic matter
P_o
P_{fix}
=P
$P_{dissolved}$
Low content organic matter
P_o
P_{fix}
=P
$P_{dissolved}$

Lower available P required at higher % SOM

Table 5.4 Effect of soil organic matter on the critical level of Olsen P for three arable crops grown on a silty clay loam soil, Rothamsted

Crop	Soil organic matter (%)	Yield at 95% of the asymptote (t ha^{-1})	Olsen P associated with the 95% yield (mg kg^{-1})	Variance accounted for (%)
Field experiments				
Spring barley grain (t ha^{-1})	2.4	5.00	16	83
	1.5	4.45	45	46
Potato tubers (t ha^{-1})	2.4	44.7	17	89
	1.5	44.1	61	72
Sugar (t ha^{-1}) from sugar beet	2.4	6.58	18	87
	1.5	6.56	32	61

Johnston et al. 2014, Adv. Agron.

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Agriculture, Ecosystems and Environment 216 (2016) 23–33

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

The long term use of farmyard manure and compost: Effects on P availability, orthophosphate sorption strength and P leaching

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ARTICLE INFO

Article history:
Received 19 February 2015
Received in revised form 31 August 2015
Accepted 12 September 2015
Available online xxx

ABSTRACT

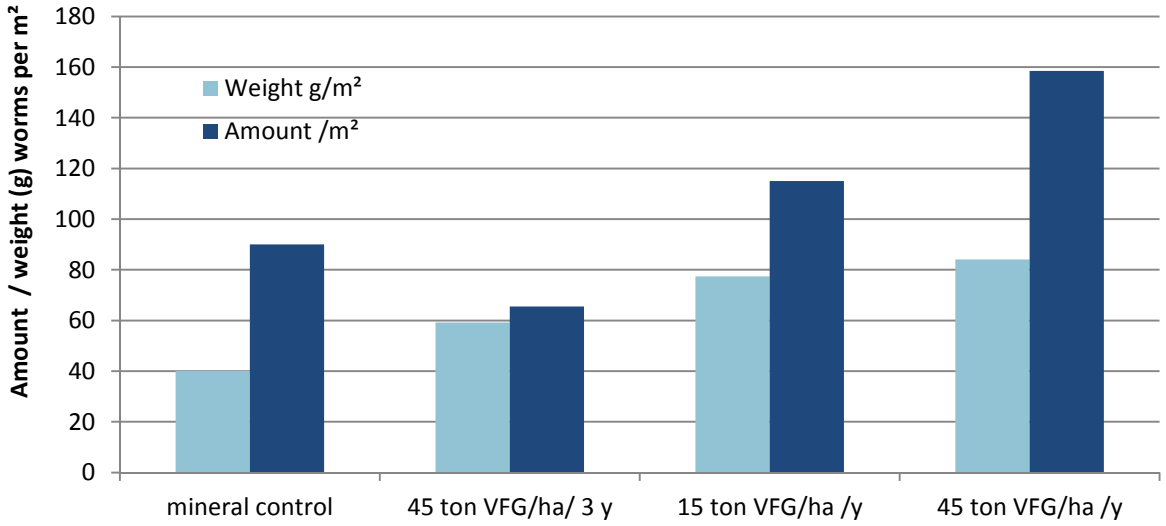
This study was set up to identify the role of dairy farmyard manure and green waste or farm compost used as a source of stable organic matter on soil P availability and P leaching. We sampled two long term field trials (8 and 16 years) on silt loam soil, with continuous amendment of dairy farmyard manure (FYM) and 6 types of organic waste (VFG, BIO), municipal solid waste (MSW), sludge (GWS) or organic farm waste (CMC1, CMC2) composts. Soil P availability was measured as 0.01 M $CaCl_2$ extractable P (P-$CaCl_2$) and hot water extractable P (HWP) and fresh subsamples were used to conduct a leaching experiment in

Conclusions

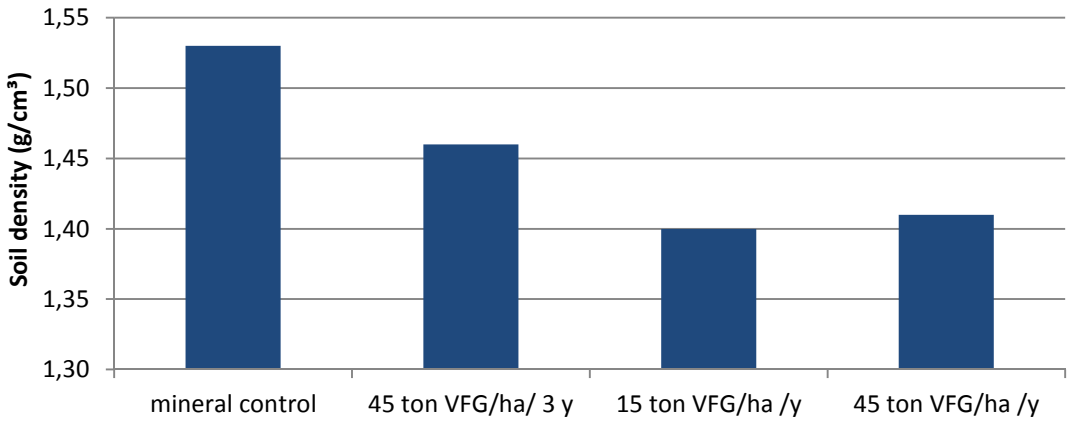
- Dose dependent retention of carbon in organic amended soils needs further attention

- Higher P availability (chemical/bioavailability) at equivalent P input of organic versus mineral P is yet unexplained and may have consequences for efficient mining of soil P

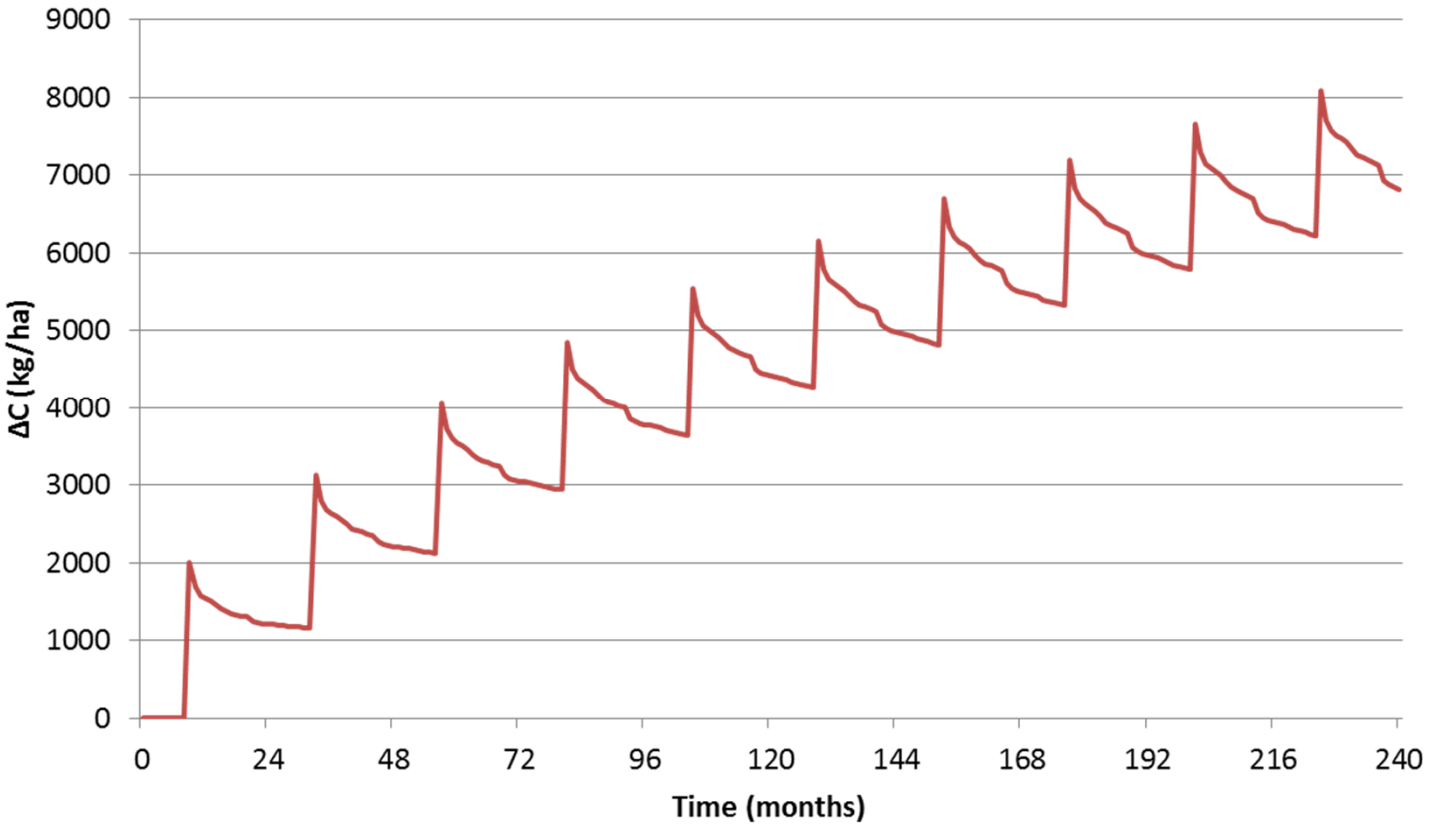
Soil Physical and Biological Effects



(Jülich, Institute of bio- and geosciences)

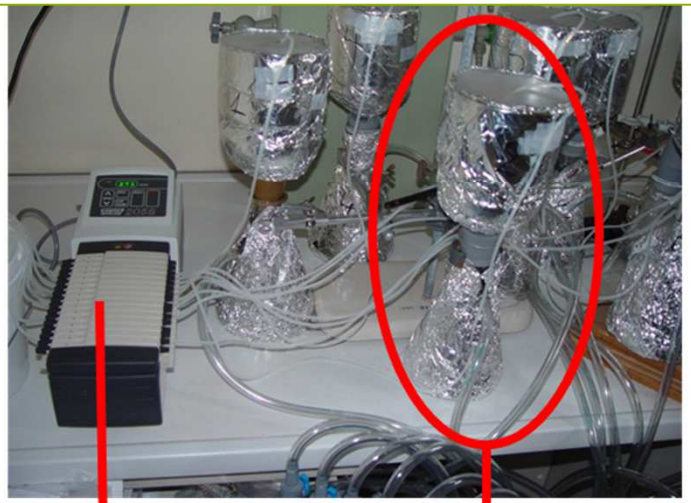


Roth-C Simulation under Standardized Temperate Climate



Carbon increase over 20y under standardized temperate climate and 2 Mg compost amendment every 2 years: 0.36 Mg/y

Research methods

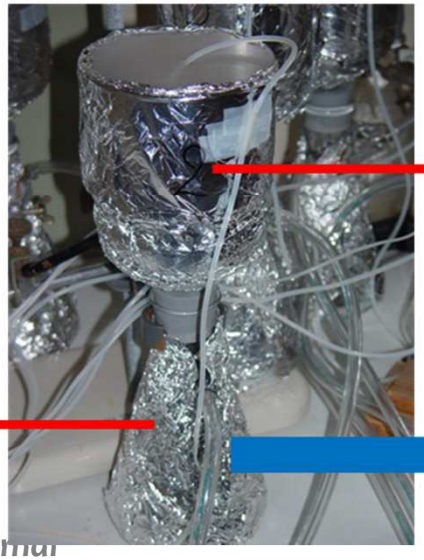


Pressure gauge

Peristaltic pump

Vacuum pump

Pressure vessel

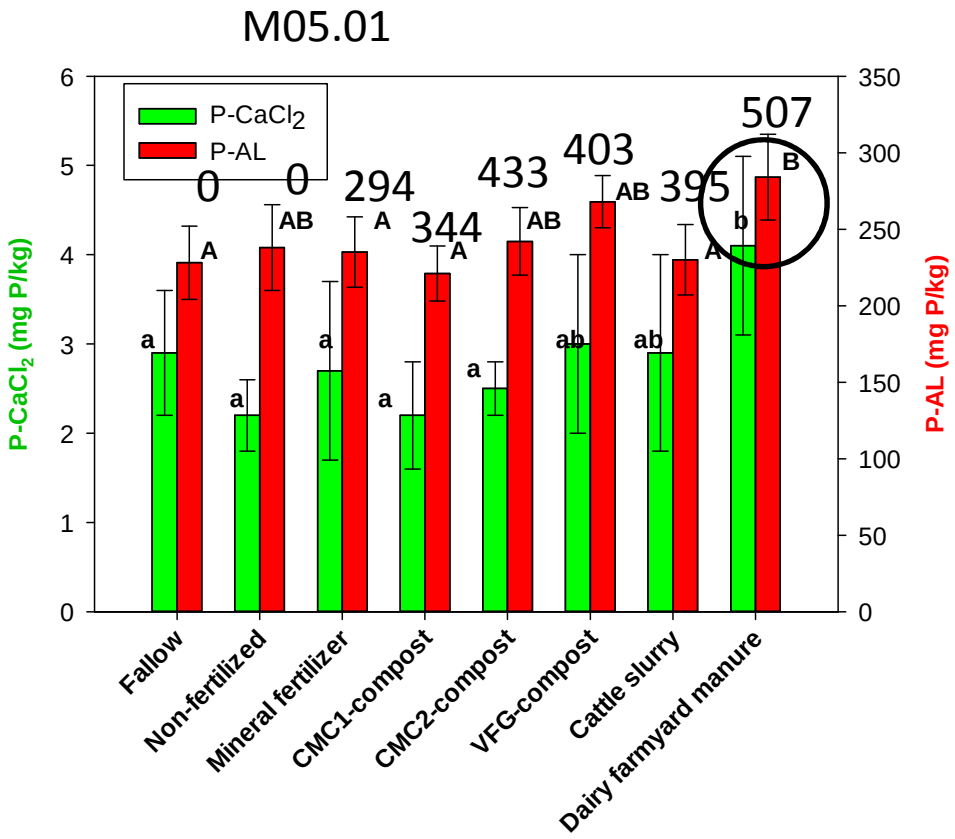


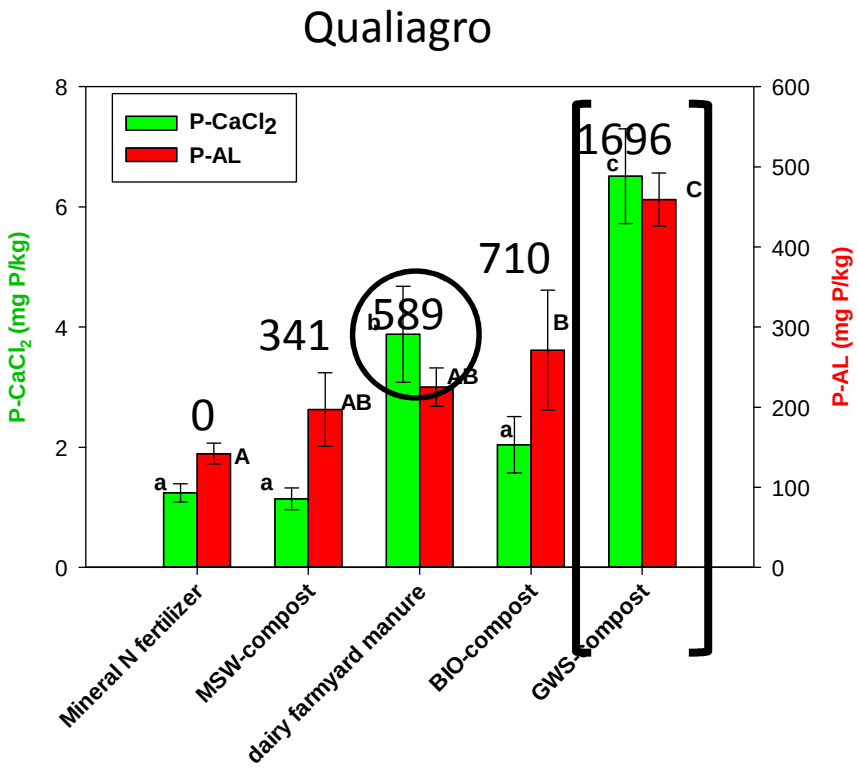
Soil column

Suction bottle

Water sample

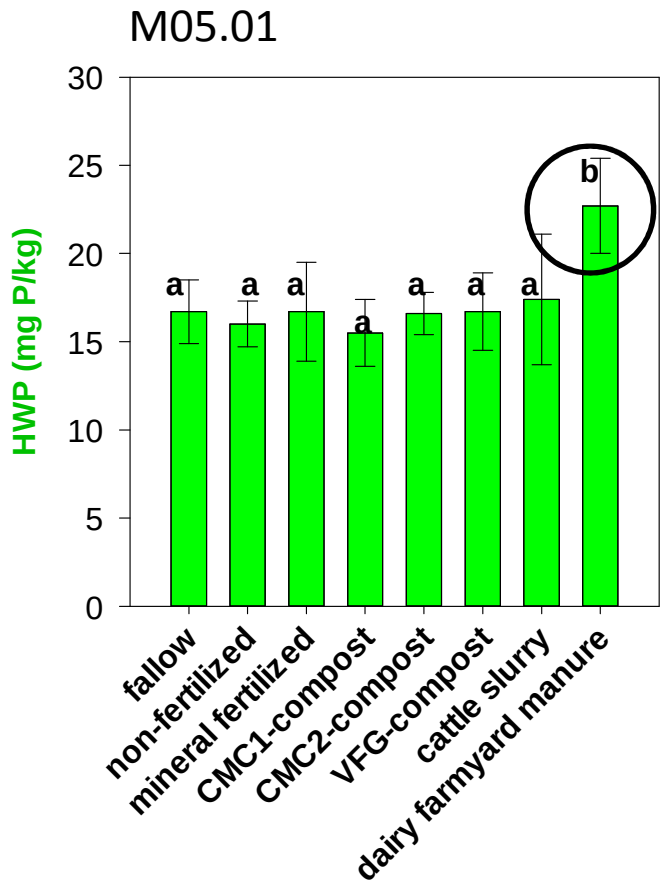
Results

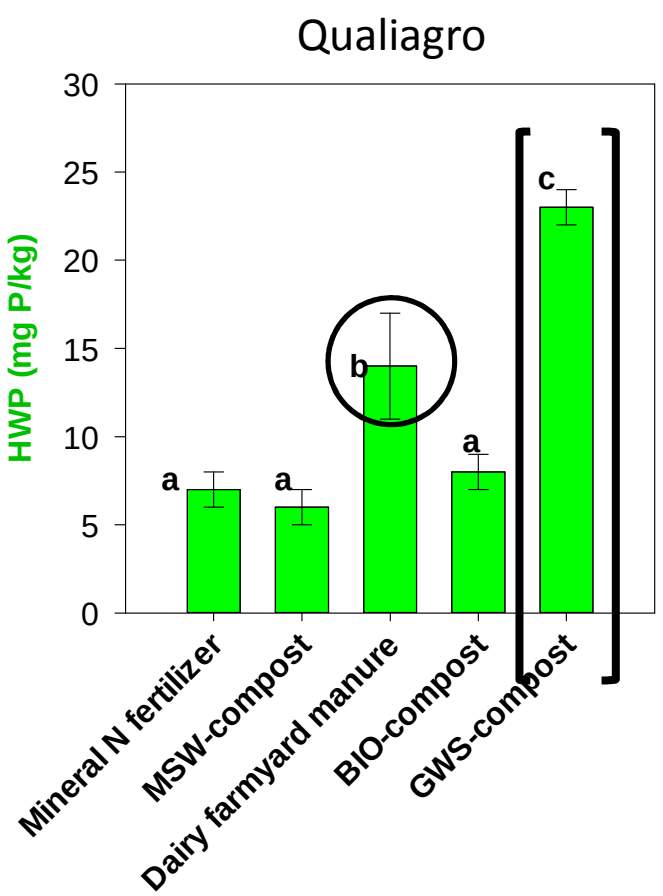




$P\text{-}CaCl_2$ is different for composts and farmyard manure

Results

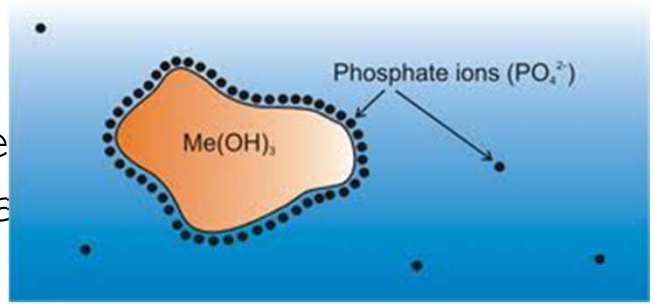




HWP determines even more than P-$CaCl_2$ the increased soil P availability in farmyard manure than in compost amended soils

Research methods

- What did we measure?
  - Soil P availability
    - HWP: hot water extractable
    - P-$CaCl_2$: 0.01 M $CaCl_2$ extra



  - Soil P stock
    - P-AL: ammonium lactate extractable P
  - P leaching
    - Laboratory leaching experiments
    - TP: P concentrations in leachates
  - Soil organic carbon (SOC%)
  - Soil acidity (pH-KCl)

Research methods

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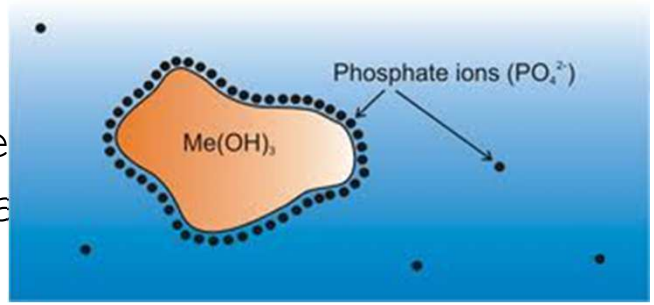

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