Decreasing CO_2 emission in agriculture by using rock flour

alternative for agricultural lime and potassium fertilisers

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Outline

- Introduction into subject
- Experiments
    1. Reactivity of Rock flours
    2. Incubation tests with olivine
    3. Field test with olivine
- Conclusions

Introduction

the idea

use of silicates to increase or maintain soil pH

- good for climate
- good for farmer if there is a reward via Carbon-trade

Introduction rock flours to replace agricultural lime *

	% emission of aglime excl LULUCF
EU15	0.12%
US	0.17%
Brazil	2.0%

- growth 3% per year; 3x in 2050 (Tilman,2001)

Potential for reducing CO_2 emission!

* UNFCCC, 2005
**emission factor $C/CaCO_3$=0.14 g/g

Introduction rock flours for climate

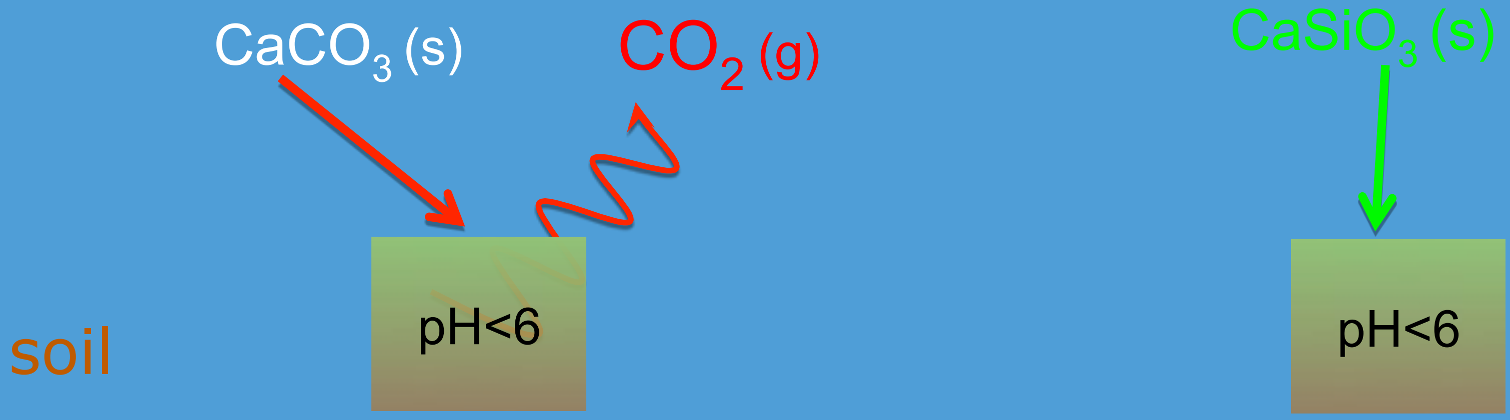
	Global effect
Replacement of current $CaCO_3$	0.12%
Replacement of KCl	0.02%
Enhanced weathering	0-5%
Increasing SOM	?

Replacement attractive compared to additional measures.

*carbon trade at €20 per ton CO_2

Introduction rock flours for climate

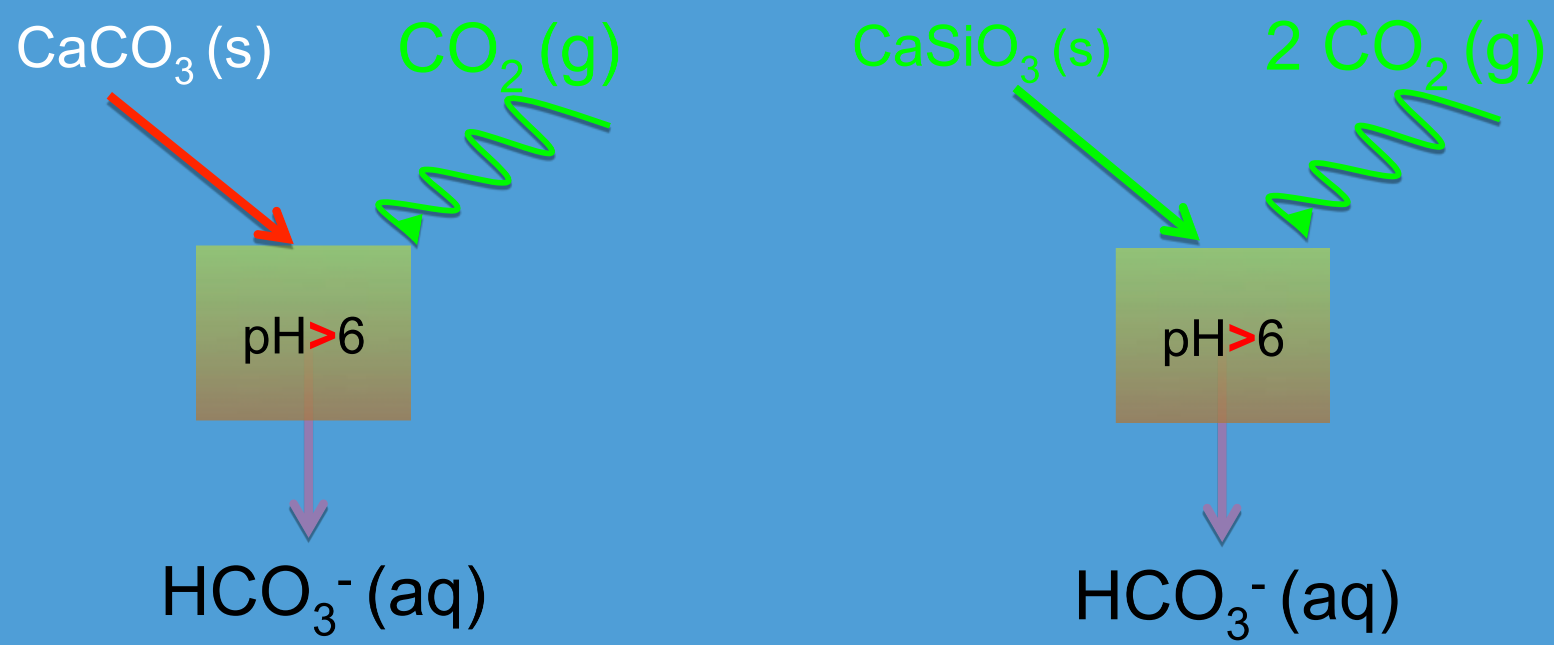
agricultural lime versus silicates



$CaCO_3 + 2\ H^+ \Rightarrow Ca^{2+} + H_2O + CO_2$ (pH< 6)

$CaSiO_3 + H_2O + 2\ H^+ \Rightarrow Ca^{2+} + H_4SiO_4$ (pH< 6)

Introduction rock flours for climate

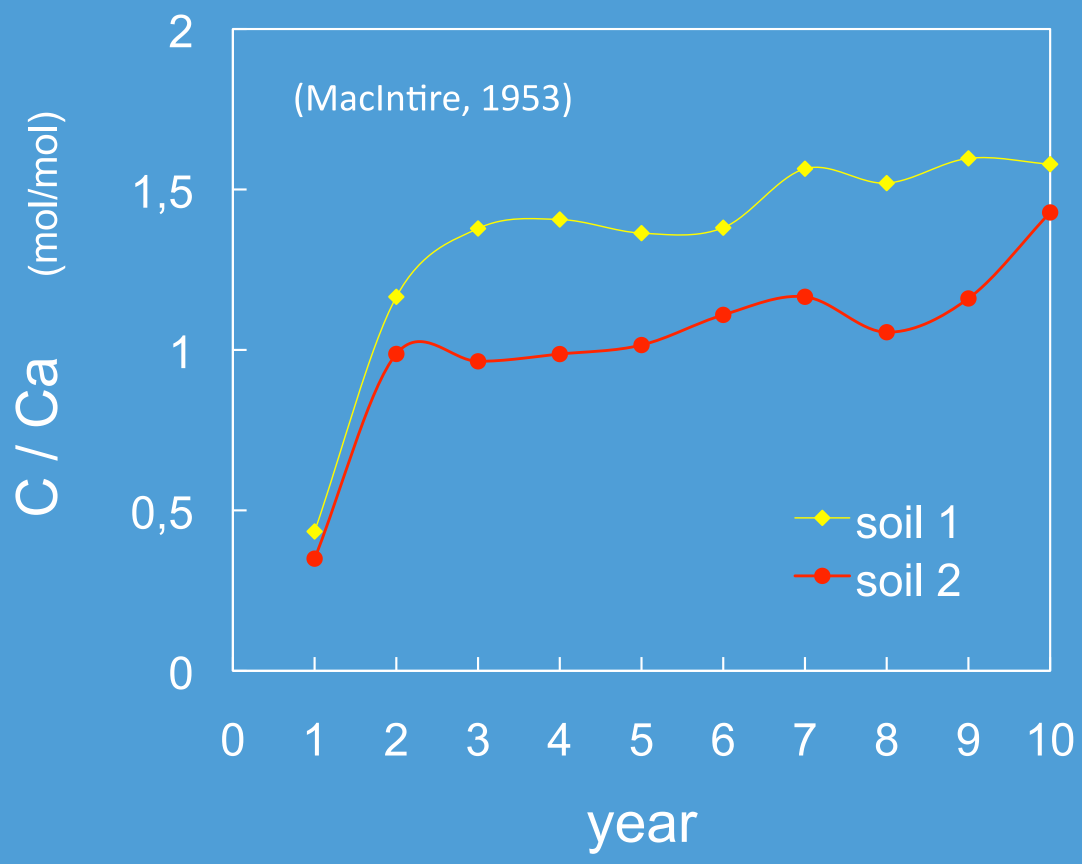


$CaCO_3 + H_2O + \mathbf{1}\ CO_2 \Rightarrow Ca^{2+} + 2\ HCO_3^-$ (pH> 6)

$CaSiO_3 + 3H_2O + \mathbf{2}\ CO_2 \Rightarrow Ca^{2+} + 2\ HCO_3^- + H_4SiO_4$ (pH> 6)

Introduction rock flours for climate: enhanced weathering

- Theory: $CaSiO_{3(s)} + 2\,CO_{2(g)} \xrightarrow{soil} 1\,Ca^{2+} + H_4SiO_{3(s)} + 2\,HCO_{3(aq)}$



Theory: **2** CO_2 per 1 Ca

Experiment at high pH: **1 to 1.5** CO_2 per 1 Ca

Introduction rock flours for agriculture

Neutralising value
K fertiliser
Mg fertiliser
Micronutrients
Bedding material for cows
Si fertiliser/protection for plant diseases

Introduction

- Relevance of CO_2 trade for rock flour? Rough estimates:

	Value per ton rock flour
Neutralising Value	€ 66
K fertiliser	€ 30
CO_2 trade	€ 3
Other values	
	€ 100 t^{-1}

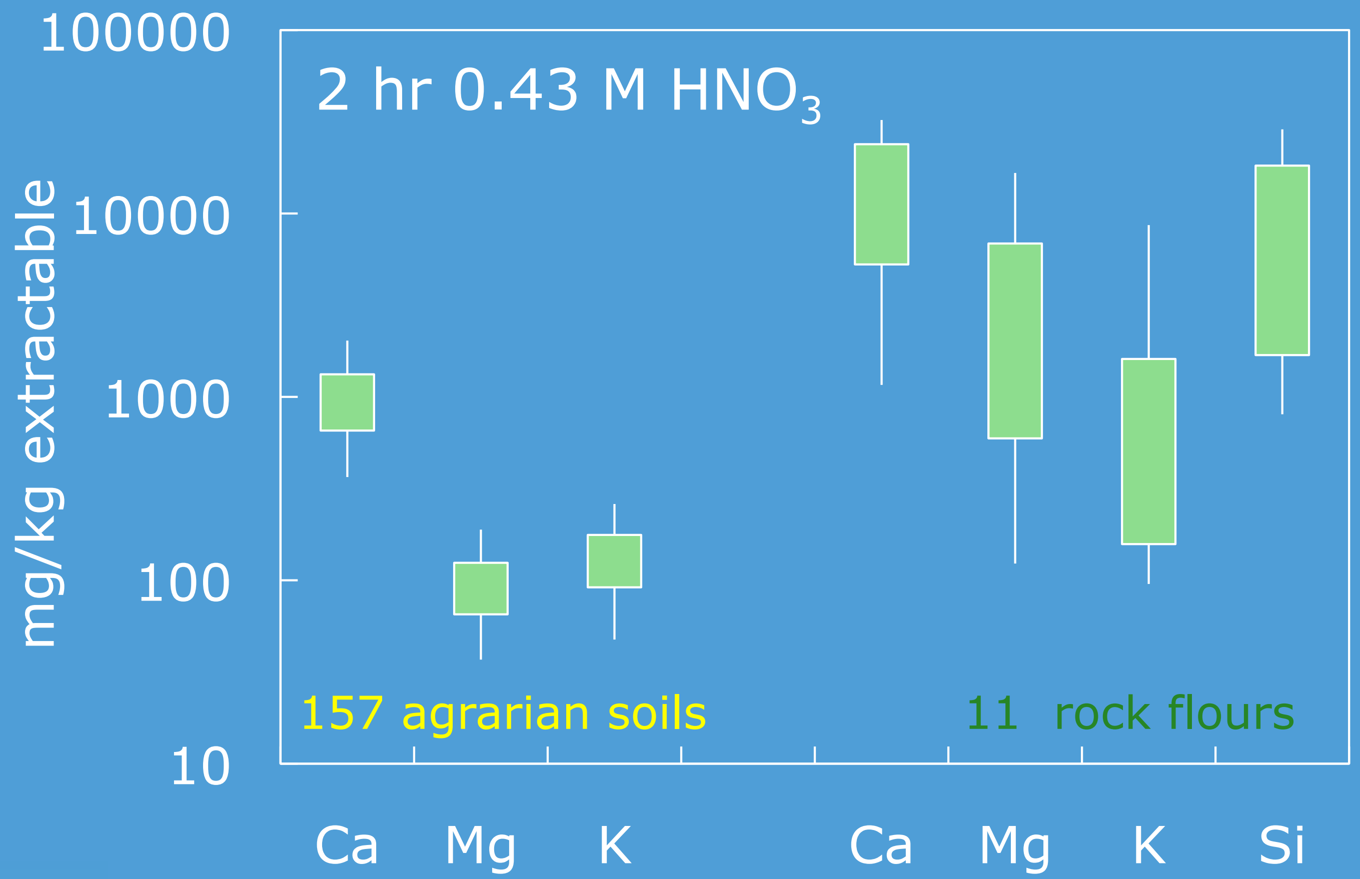
- Value to farmer determines if CO_2 reduction is cheap
- "liming"value is important for rock flour

Experiments

1. Reactivity of rock flours
2. Incubation tests with olivine
3. Field test with olivine

Experiments

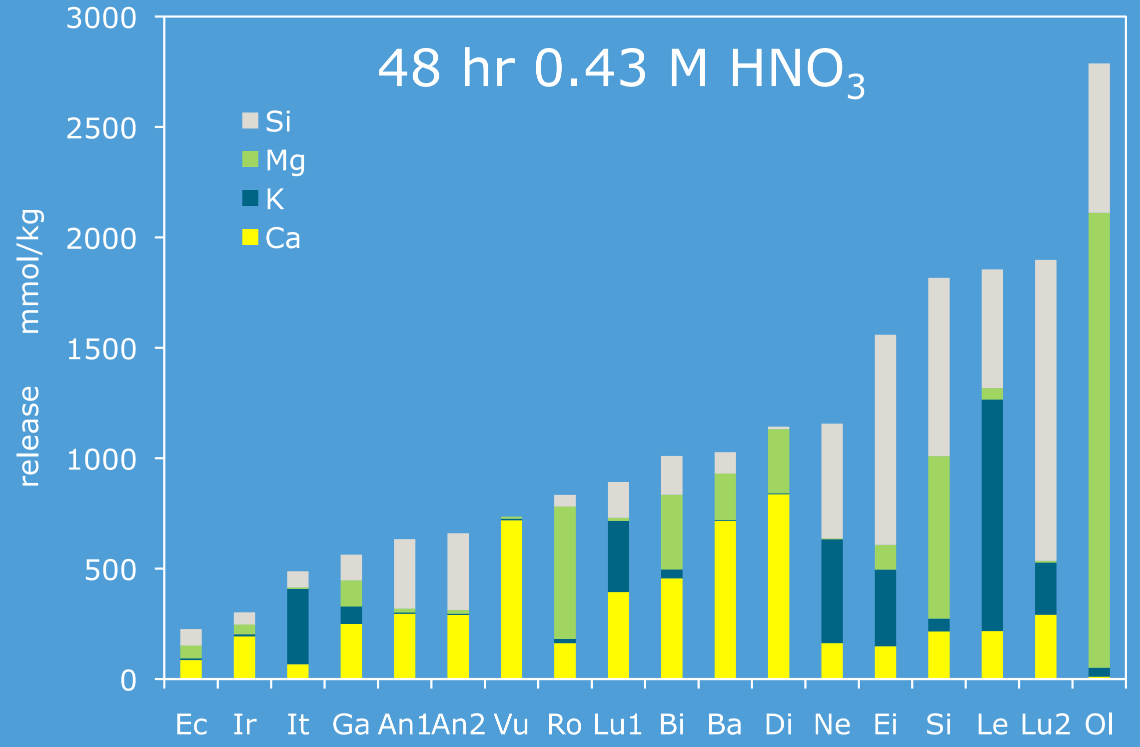
comparing rock flours with soils



- +1% rock flour to sandy soil = +100% Ca, Mg, K

Experiments

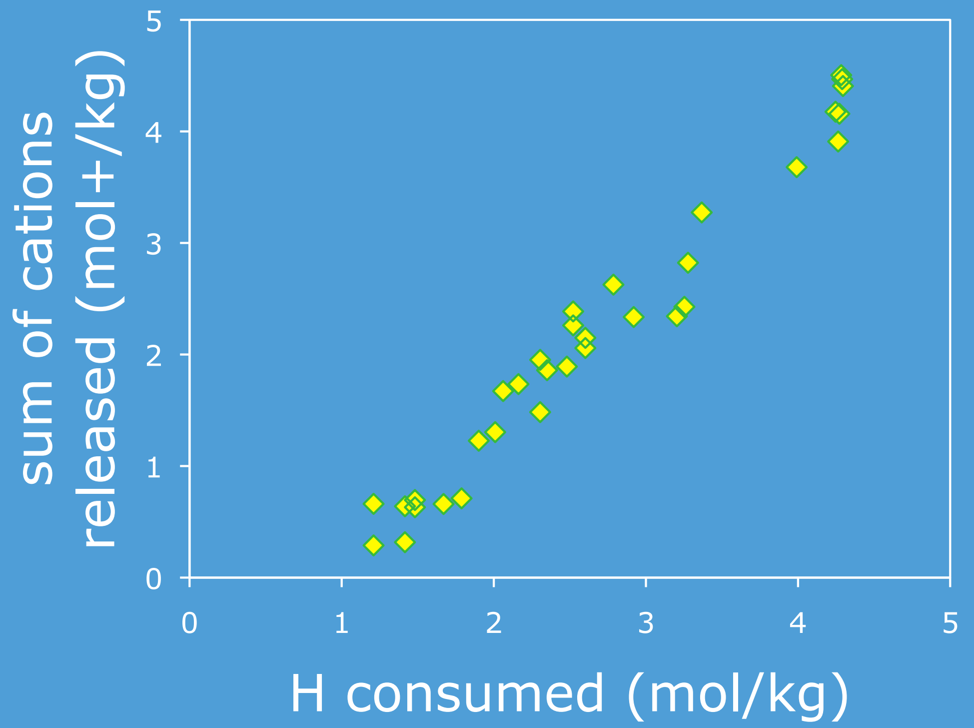
comparing rock flours



- Large differences between rock flours

Experiments

comparing rock flours



- Release of cations = H consumption

Experiments

comparing rock flours

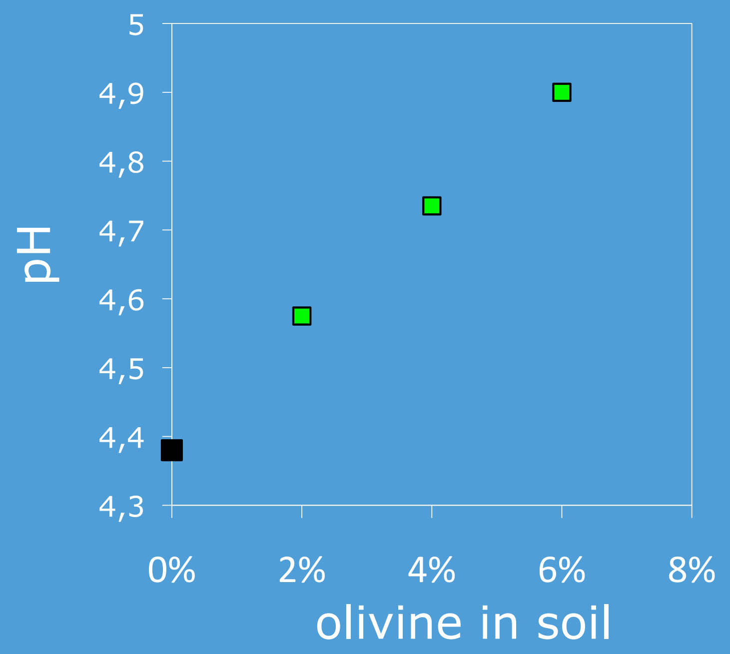
	Lime=100% % "CaCO3"
Ga	9
Ir	11
Ne	12
Ei	16
Ro	18
Bi	19
Ba	19
Vu	22
Le	22
Di	23
Si	33
olivine	64

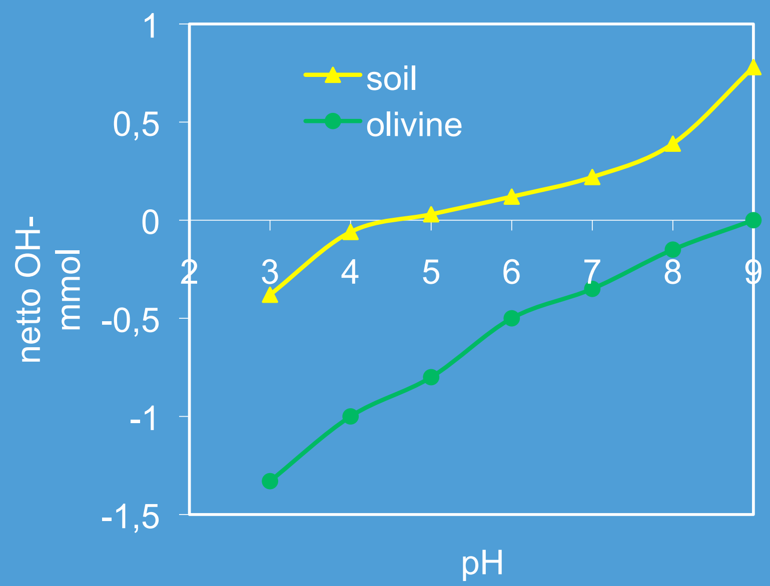
- According to EN 12945

- Neutralising value of rock flour is relevant

Experiments

laboratory incubation tests

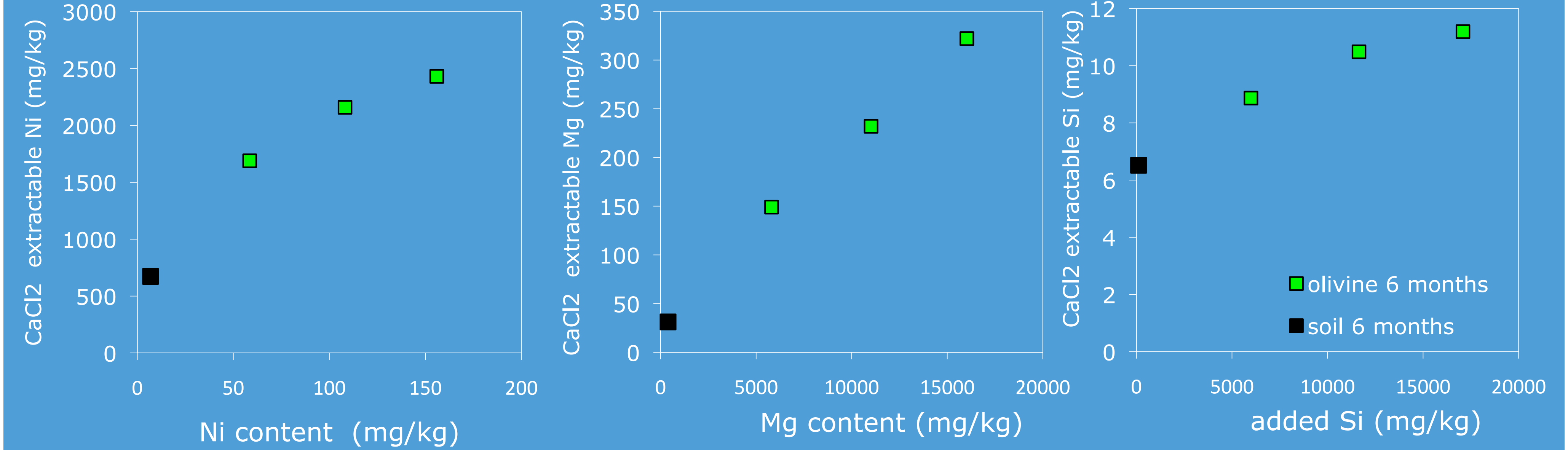




- more olivine rock flour in soil -> higher pH
- explained by surface reaction ≠weathering

Experiments

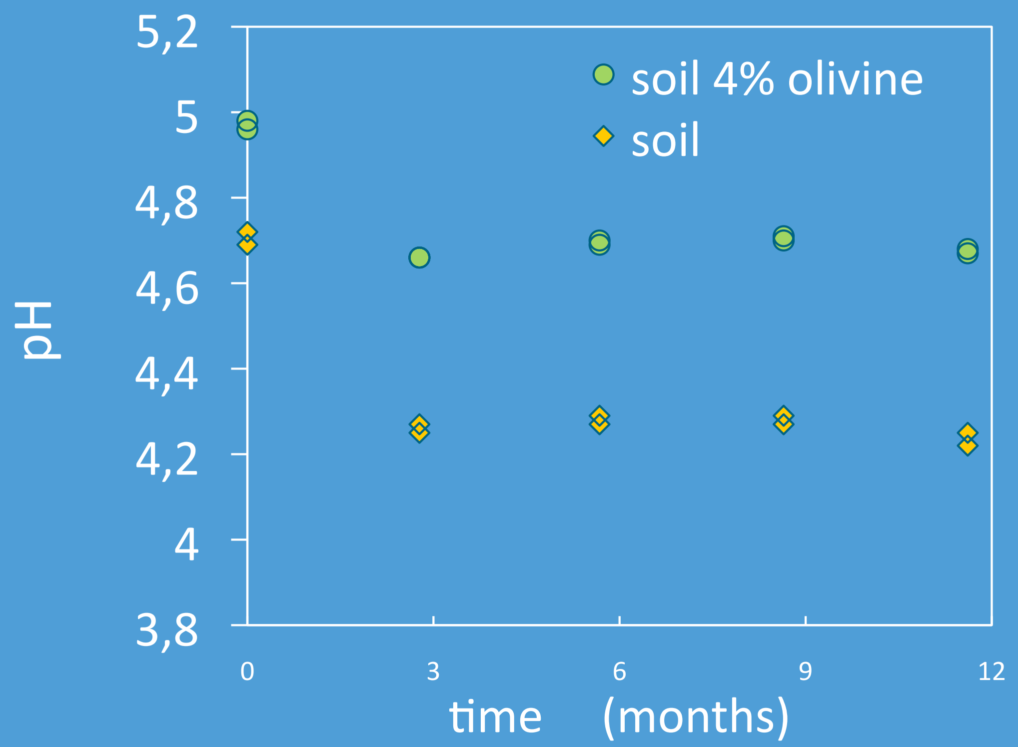
laboratory incubation tests



- more olivine rock flour in soil, more available Mg, Si, Ni
- Olivine is not allowed in Dutch agriculture

Experiments

laboratory incubation tests



- Initial pH effect = effect after 1 year

Field experiment: 3 years

treatment		Amounts kg ha^{-1}
a.	blanc	0
b.	kieserite ($MgSO_4$)	125
c.	lime($CaCO_3$ $MgCO_3$)	2111
d.	olivine ($MgSiO_4$)	215
e.	olivine ($MgSiO_4$)	2111
f.	olivine ($MgSiO_4$)	8333
g.	rock flours (eclogite+syenite)	8333

-Standard fertilisation with NK

-no K for the treatment with rock flour

Field experiment

Peat soil, triplicate, 5 cuts per year, plot size=18 m^2

Field experiment, magnesium in grass g kg^{-1}

treatment	2010	2011	2012
Blanc treatment	2.0	1.8	1.6 a
Kieserite ($MgSO_4$)	2.2	1.8	1.6 a
lime($CaCO_3$ $MgCO_3$)	2.2	2.0	1.8 ab
Olivine 1 ($MgSiO_4$)	2.2	1.8	1.7 ab
Olivine 2	2.3	1.7	1.8 ab
Olivine 3	2.7	2.2	2.0 b
Rock flour	2.3	2.1	2.0 b

- Target for Mg in grass is reached (2-3 g kg^{-1} ds)

Field experiment, pH of soil

treatment	2010	2011	2012
Blanc treatment	4.4	4.5	4.3 a
Kieserite ($MgSO_4$)	4.3	4.5	4.4 ab
lime($CaCO_3$ $MgCO_3$)	4.8	5.0	4.8 c
Olivine 1 ($MgSiO_4$)	4.4	4.5	4.4 ab
Olivine 2	4.4	4.5	4.4 ab
Olivine 3	4.7	4.8	4.8 c
Rock flour	4.7	4.7	4.6 bc

- Lime, olivine and rock flour increase soil pH in field

Experiments

all together: lab tests and field experiment

- Amounts necessary to get the same effect as lime

	olivine/lime (kg/kg)	Rock flour/lime (kg/kg)
test neutralising value EN 12945	1.5	11
Incubation test (sandy soil)	35	
Field (peat soil) in 2010	4	4
Field (peat soil) in 2011	7	12

- Rock flour and olivine work very well in the field

Conclusion of experiments

- Rock flours can have the same function as lime
- Verification of the pH effect on the long term is necessary
- Rock flours can deliver nutrients to plants
- There is a large variation in rock flours

Conclusion

- Success or failure of using rock flours for CO_2 trade depends on the agronomical value
- The agronomical value is based on the neutralisation + K and other factors.
- Bulk prices are unknown, it is still a niche market.

Thanks

and to be continued...

- Province of Utrecht
- Experimental farm Zegveld
- Novasaxum bv
- Arcadis bv
- Ministery of Economic Affairs