Long-term effect of various fertilizing strategies on soil organic carbon, crop yield, soil P availability and potential P leaching

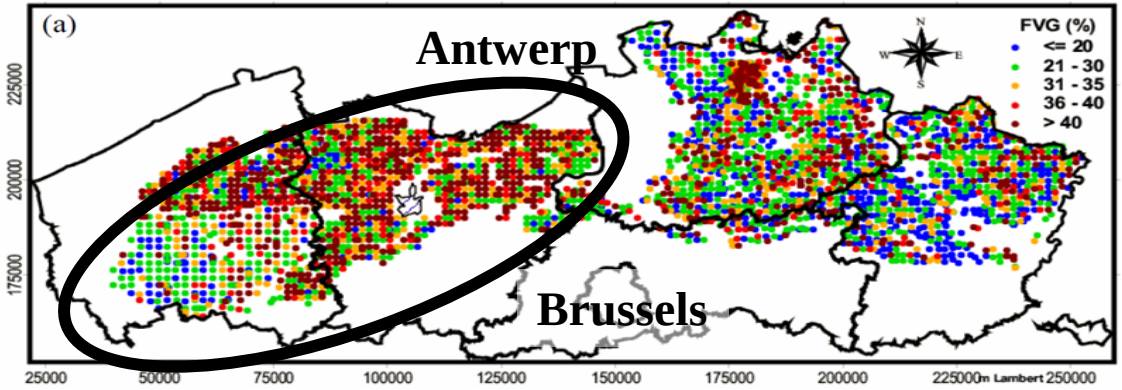
Thijs Vanden Nest

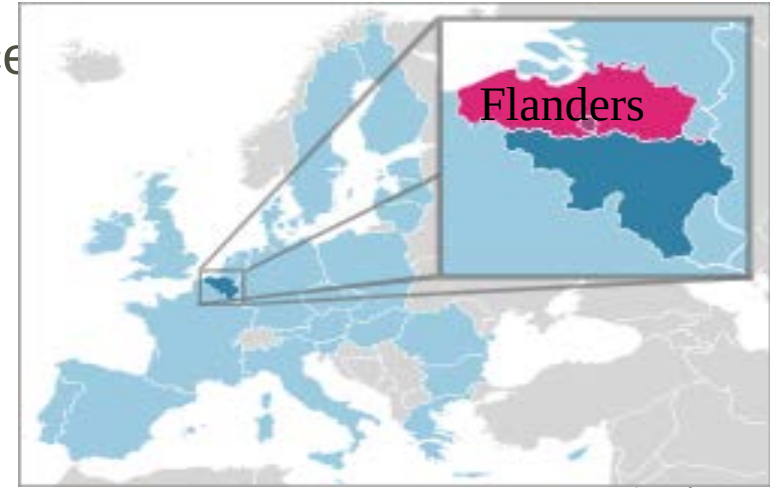
September 2013
International Phosphorus Workshop – Uppsala, Sweden

Institute for Agricultural and Fisheries Research
Plant Sciences Unit
www.ilvo.vlaanderen.be
Agriculture and Fisheries Policy Area

Situation in Flanders

- 625 000 ha UAA (sandy, sandy loam, loam and clay soils)
- 1 300 000 cows, 6 000 000 pigs and 27 000 000 poultry
- 49 000 000 kg P_2O_5 fertilizer use (96% animal manure)
- 6 kg P_2O_5/ha surplus
- harbours → import of (protein rich) feed
- **Large livestocks** + **intensive vegetable production** on sandy soils
- **Historical overfertilization**
- Important restrictions on fertilizer use since





Research goal

Which organic fertilizers or fertilizer strategy lead

(1) to more soil organic Carbon

without

(2) increasing the Phosphorus leaching

at the same time?

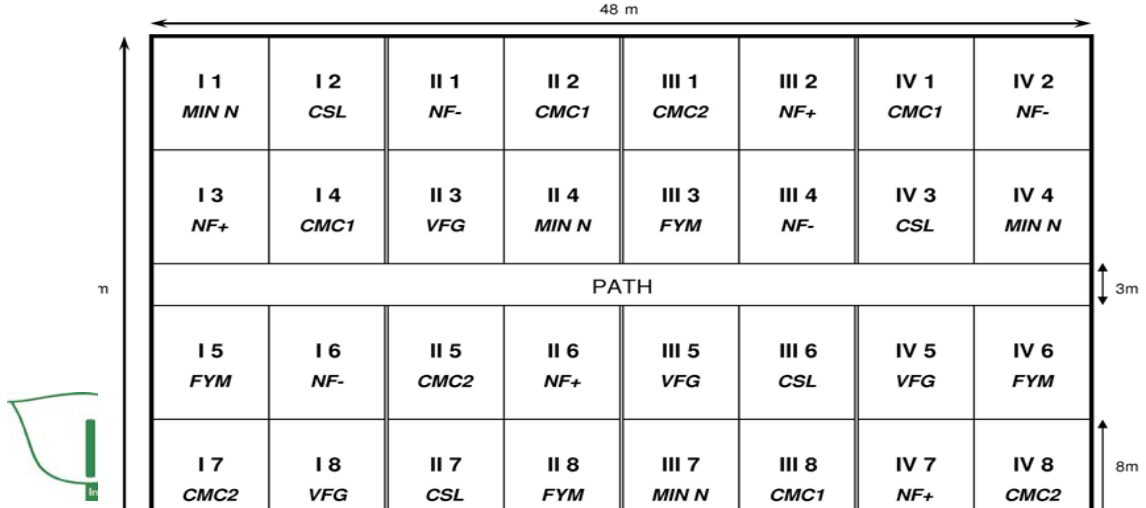
Some pictures…

Outline

- Field experiment set-up
- Soil and plant parameters
- Results:
  - Crop yield
  - P-export
  - P-availability
  - TOC% and HWC
  - pH-KCl
- Potential P leaching
- Discussion and conclusion

Field experiment set-up

- 2005, Ghent University
- 50 59'N, 03 49'E, 11 m above sea level
- Silt loam soil (USDA), sandy loam soil (Belgian classification)
- Randomized complete block design (4 replications)
- Conventional agriculture in reduced tillage (30 cm depth)
- Earlier research topics
- = soil quality (physical and biological)



Year	Crop
2005	Fodder beet
2006	Winter Wheat (+phacelia)
2007	Red cabbage
2008	Perennial ryegrass
2009	Maize
2010	Fodder beet
2011	Red cabbage
2012	Potatoes (+ Rye)
2013	Maize

Field experiment set-up

- N-balance method:
  - N crop requirements
  - Residual N before planting/sowing
  - N mineralization (incubation experiment)
  - N working coefficient
- C input of FYM, VFG, CMC1 and CMC2 equalized to CSL
- Additional NPK if required
- Max 100 kg P_2O_5/ha.yr
- Max 300 kg K_2O/ha.yr

Label	Treatment
NF-	No fertilizers + no crop
NF+	No fertilizers
MIN N	NPK mineral fertilizers
CSL	Cattle lurry (+NPK)
FYM	Farmyard manure (+NPK)
VFG	Vegetable, fruit and garden compost (+NPK)
CMC1	Farm compost (high C/N) (+NPK)
CMC2	Farm compost (low C/N) (+NPK)

ILVO
Instituut voor Landbouw- en Visserijonderzoek

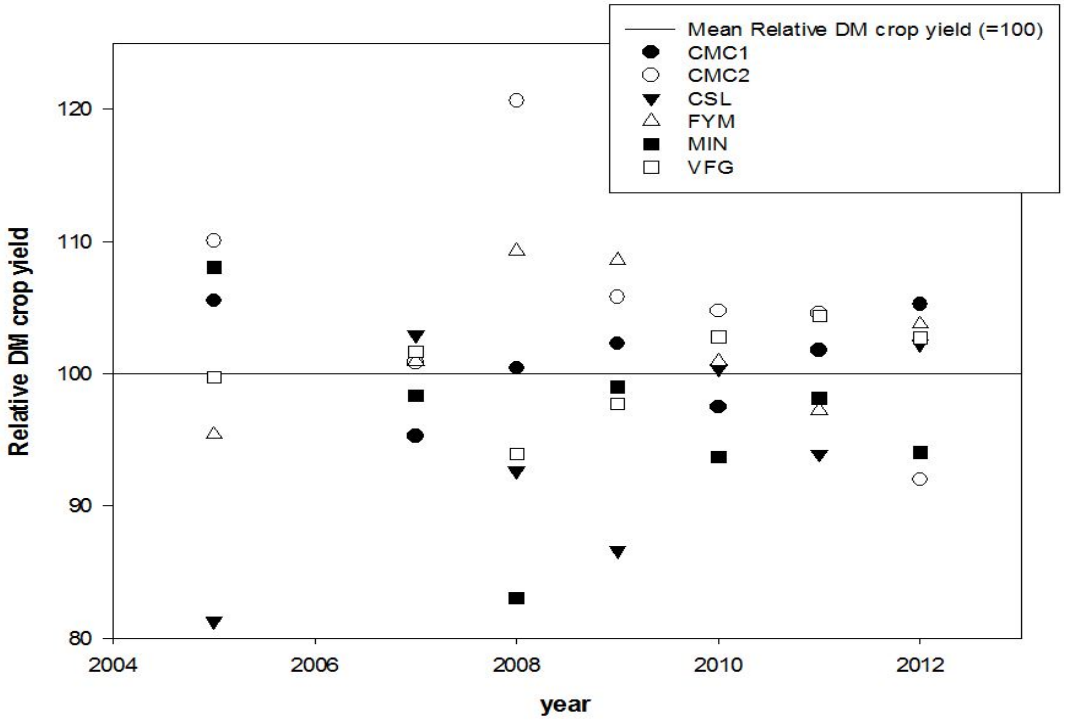
C and P input (2005-2012)

	Treatment	Total P input (kg/ha)	Org fertilizer P input (kg/ha)	Total C input (kg/ha)	C (g/kg fresh)	N (g/kg fresh)	P (g/kg fresh)	C/P
FYM	Farmyard manure	551	459	23911	89.0	4.9	1.5	67
VFG	VFG-compost	446	375	23911	149.4	11.5	2.4	75
CMC1	CMC1-compost	388	235	23911	100.5	3.9	0.8	156
CMC2	CMC2-compost	477	366	23911	81.4	5.9	1.1	107
CSL	Cattle slurry	444	419	23911	31.2	3.8	0.6	53
MIN N	Mineral fertilizers	338	0	0	-	-	-	-
NF+	No fertilizers	0	0	0	-	-	-	-
NF-	Fallow	0	0	0	-	-	-	-

Soil and Plant parameters

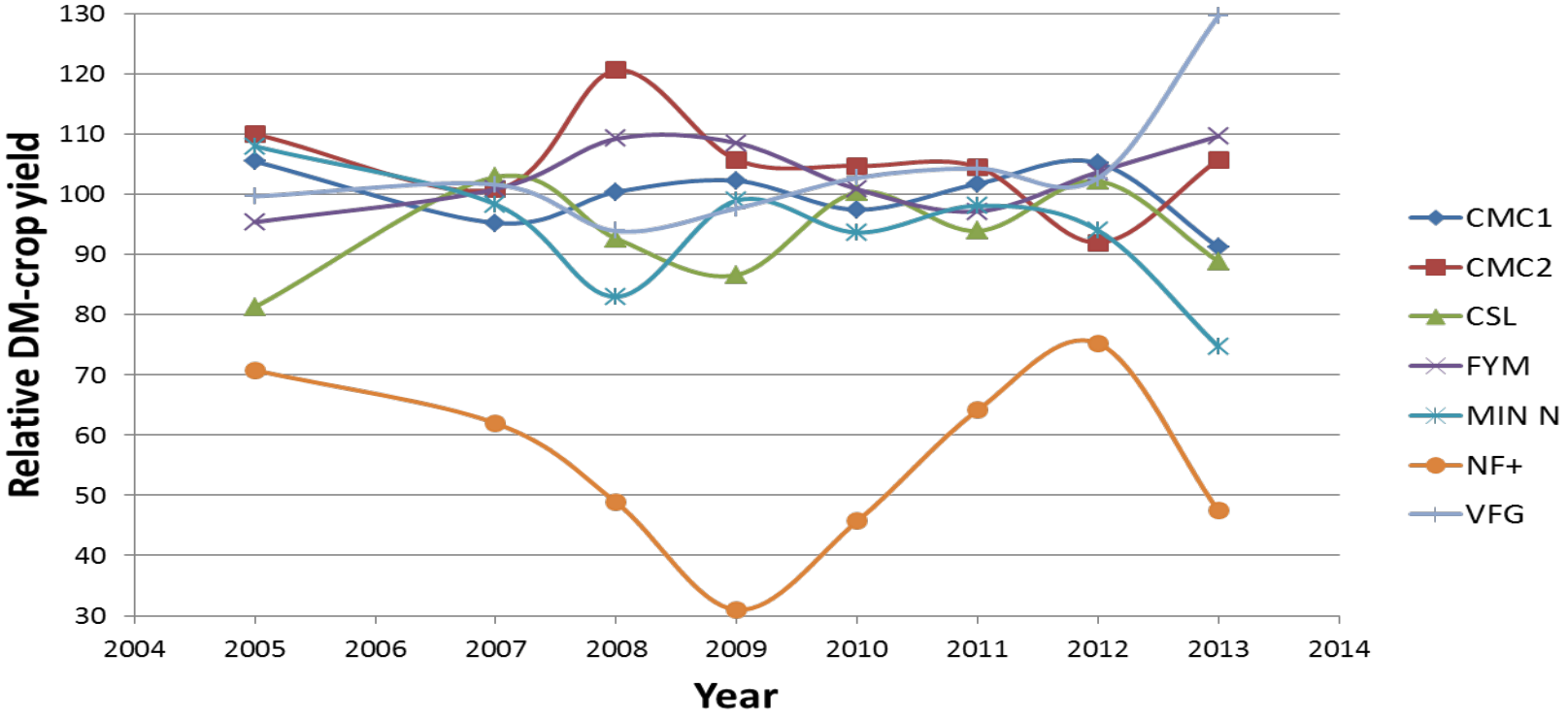
- P-$CaCl_2$ (0,01M $CaCl_2$)
  → P availability, P in soil solution
- P-AL (P ammonium lactate, pH 3.75)
  → agricultural P parameter
- HWP (hot water)
  → labile P forms
- Ptot (aqua regia)
- (P saturation degree)
- Crop yield + P export
- Other parameters: Ca-AL, Fe-AL, pH-KCl, TOC and HWC

Crop yield (2005-2012)

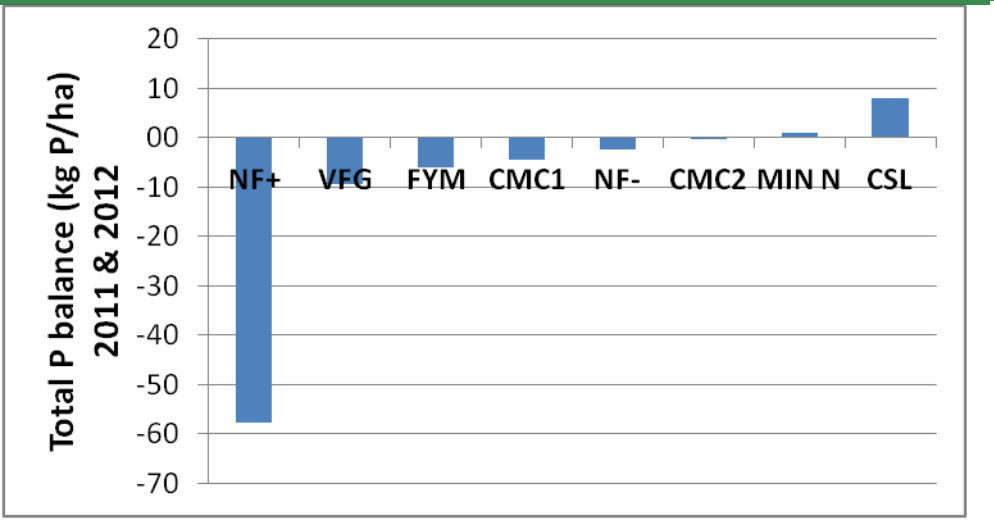


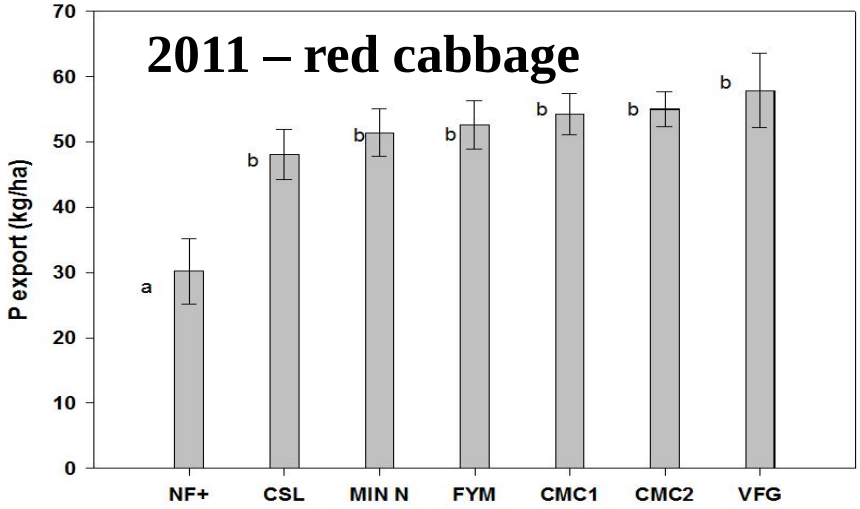
CSL (94)^{a} < MIN N (96)^{ab} < VFG (100)^{ab} < CMC1 (101)^{ab} < FYM (102)^{ab} < CMC 2 (106)^{b}

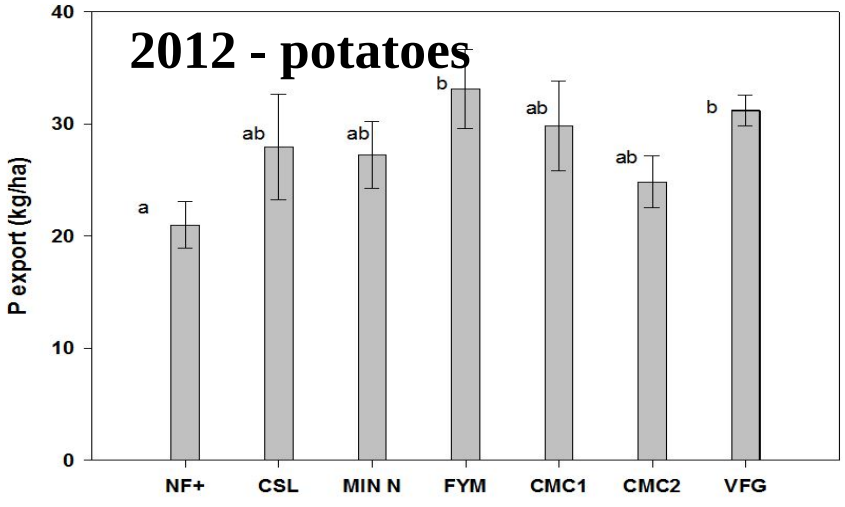
Crop yield (2005-2012)



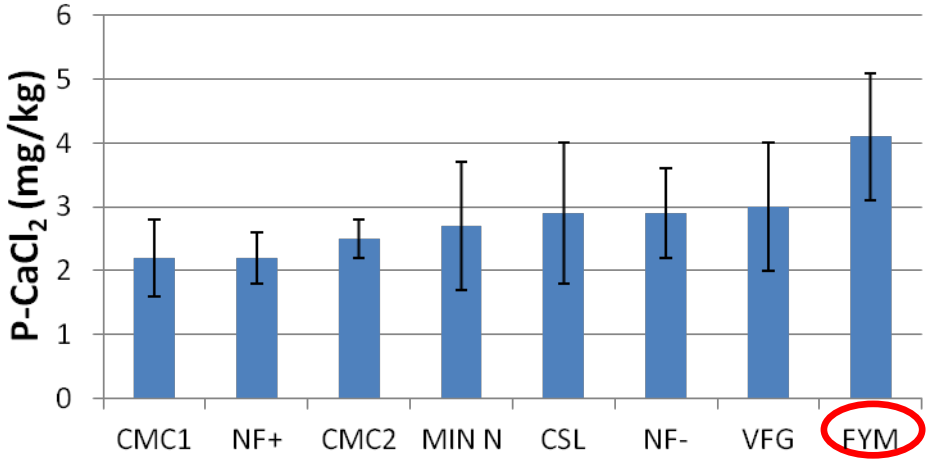
P export (2011-2012)

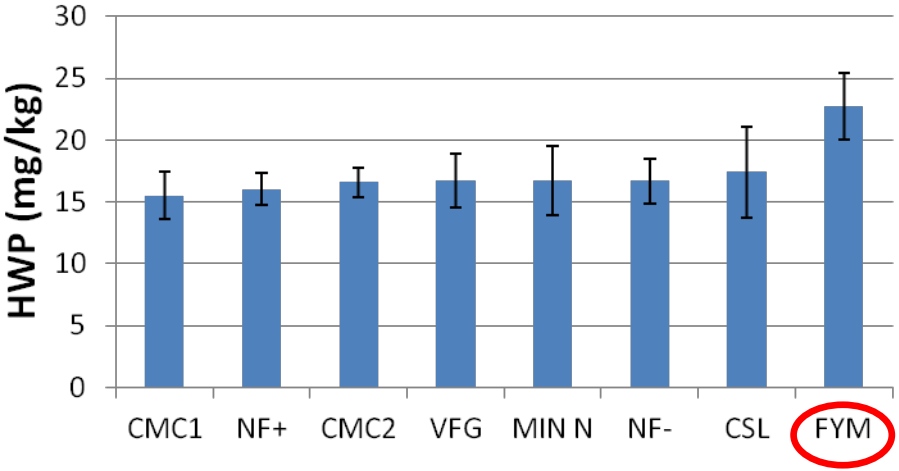


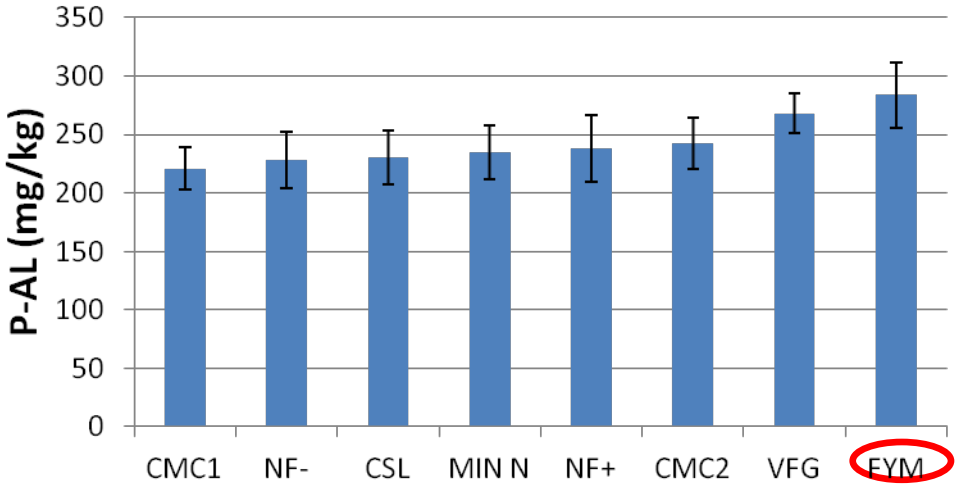




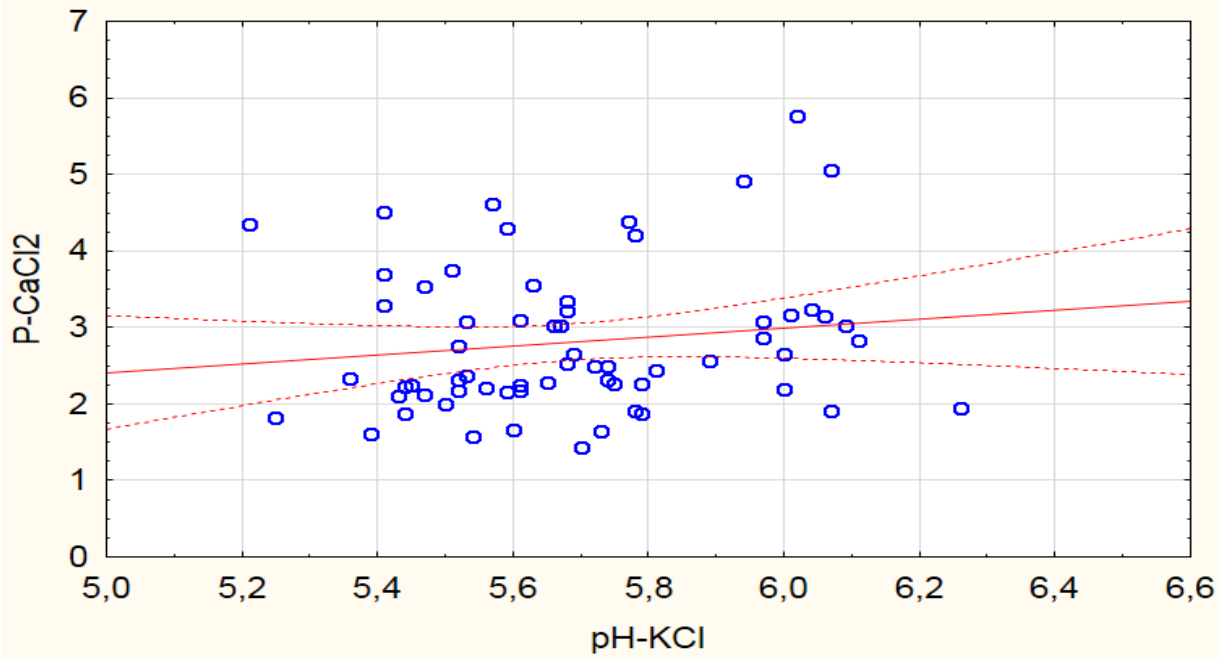
P-availability (2011-2012)







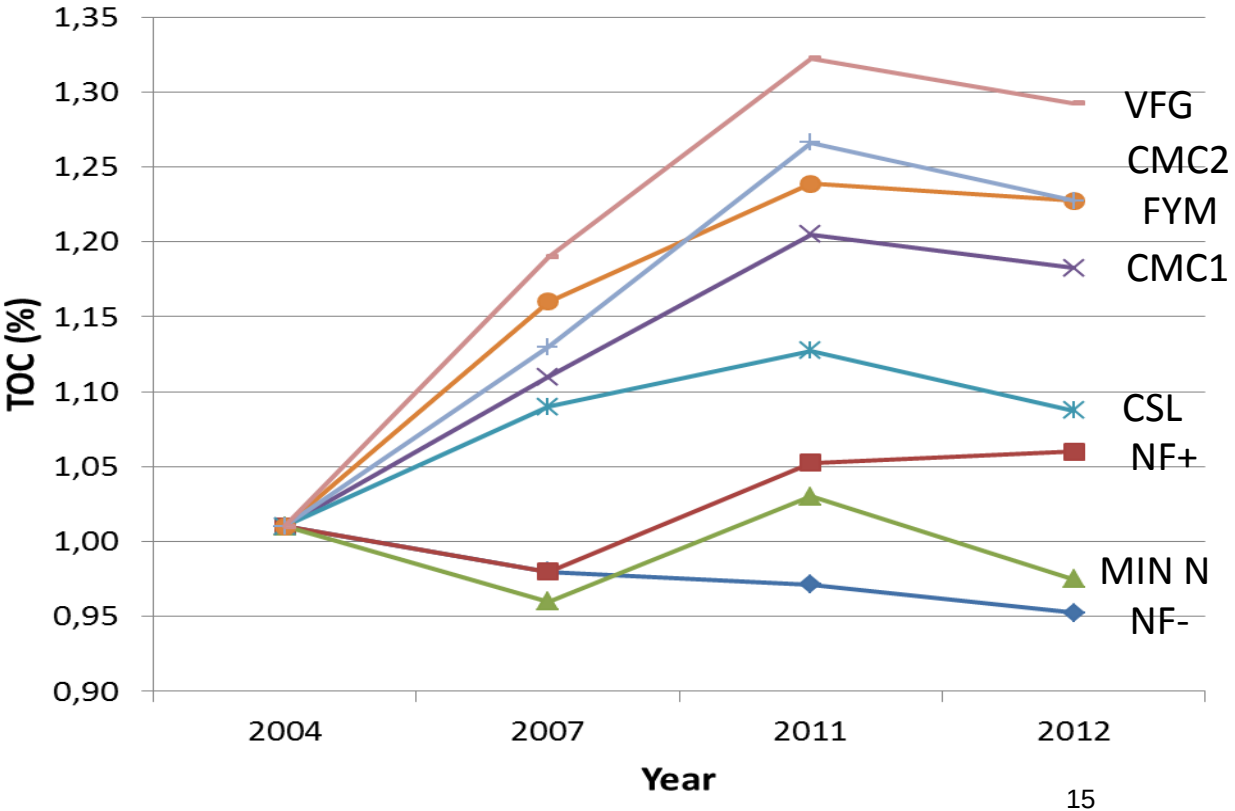
pH-KCl



Treatment	pH-KCl
FYM	5.82^{c}
VFG	6.09^{d}
CMC1	5.67^{bc}
CMC2	5.83^{c}
CSL	5.64^{abc}
MIN N	5.42^{a}
NF+	5.46^{ab}
NF-	5.58^{ab}

TOC and HWC (2011-2012)

Fertilizer	HWC 2011 (mg/kg)	HWC 2012 (mg/kg)
NF-	755[a]	556[a]
MIN N	804[ab]	542[a]
NF+	847[abc]	741[a]
CMC2	936[abcd]	773[a]
CMC1	944[bcd]	733[a]
CSL	993[cd]	609[a]
VFG	1011[cd]	658[a]
FYM	1032[d]	641[a]



Potential P leaching

Pressure gauge

Peristaltic pump

Vacuum pump

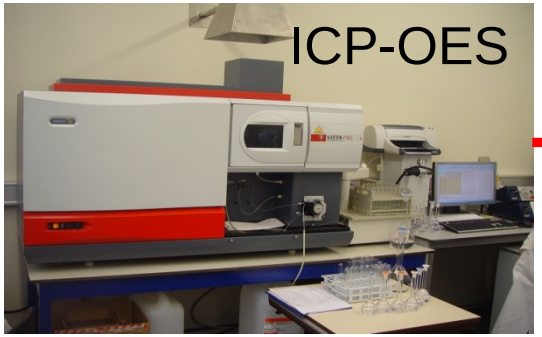
Pressure vessel

Soil column

Suction bottle

Water sample

Potential P leaching



Total P

Water sample

Ortho-P

NO_3^-

TDP

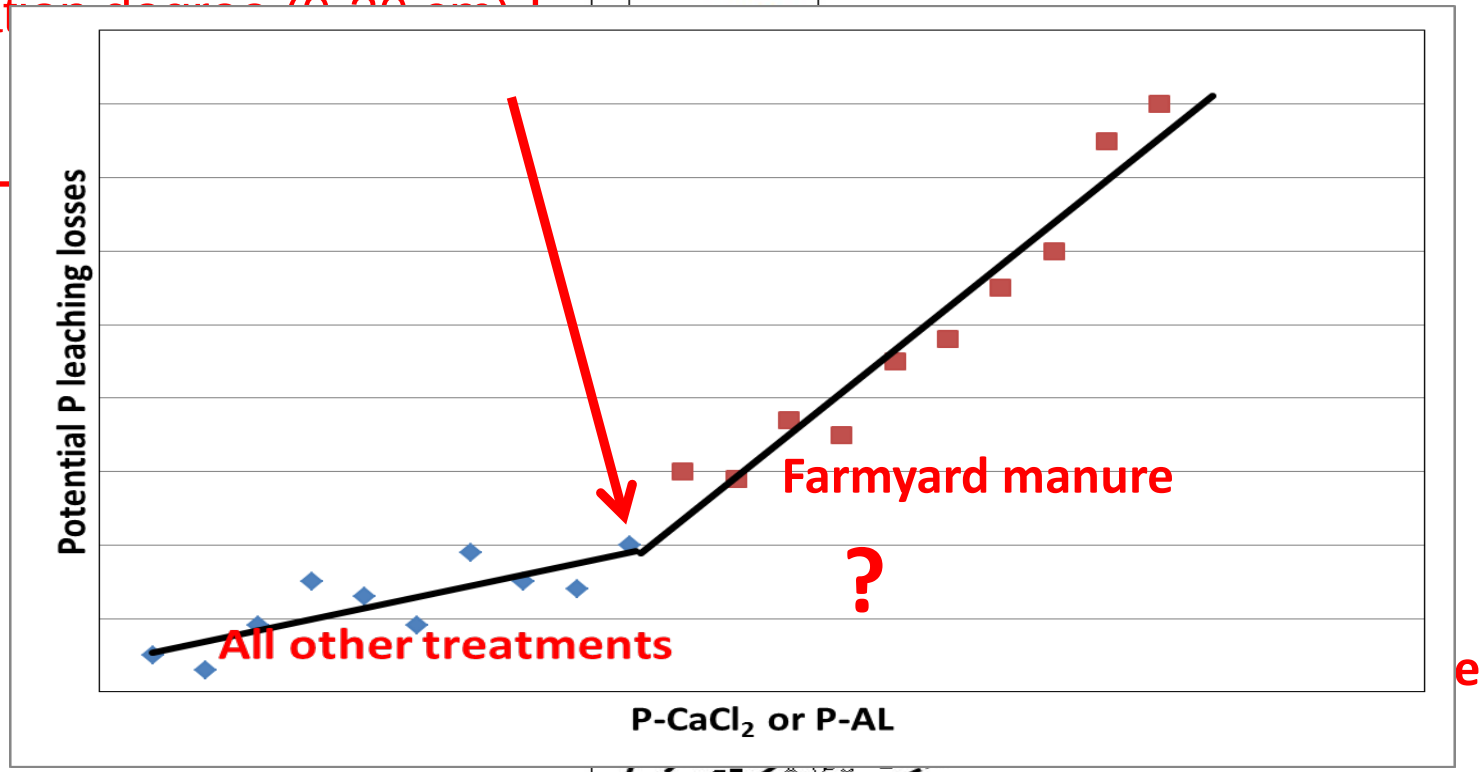
TDC

Fe

Potential P leaching

P saturat

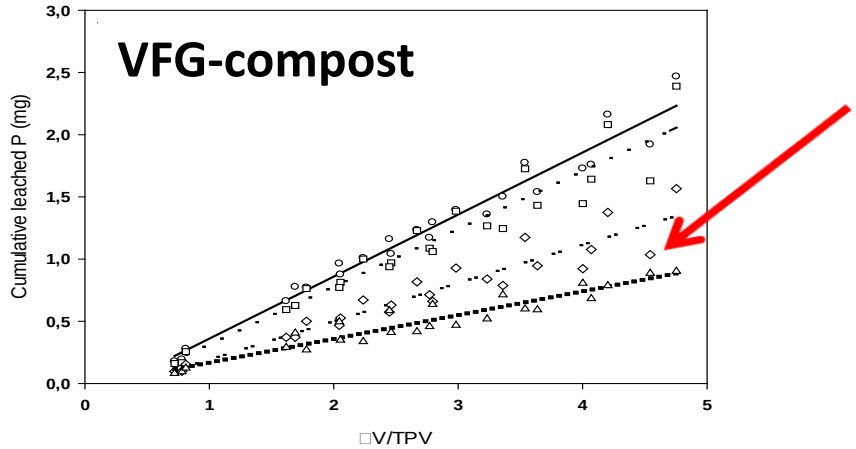
FYM =

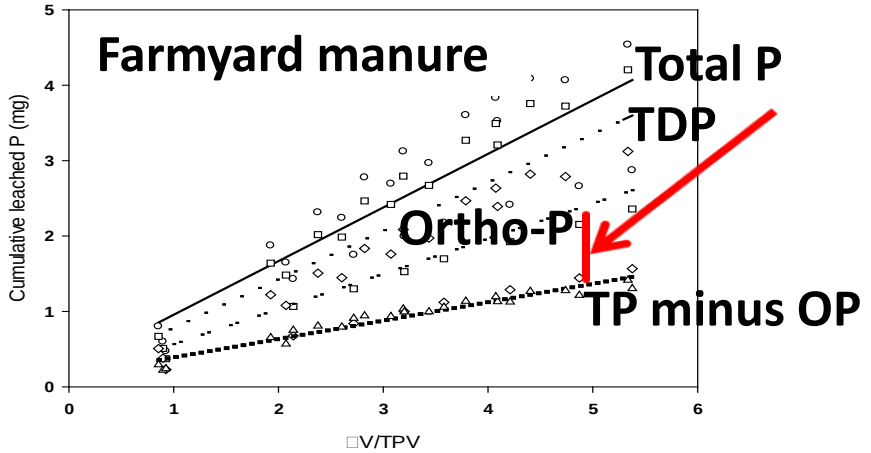


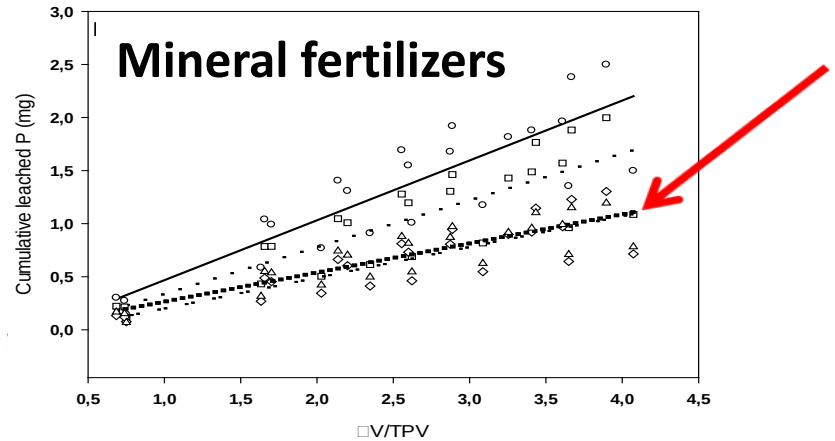
ents

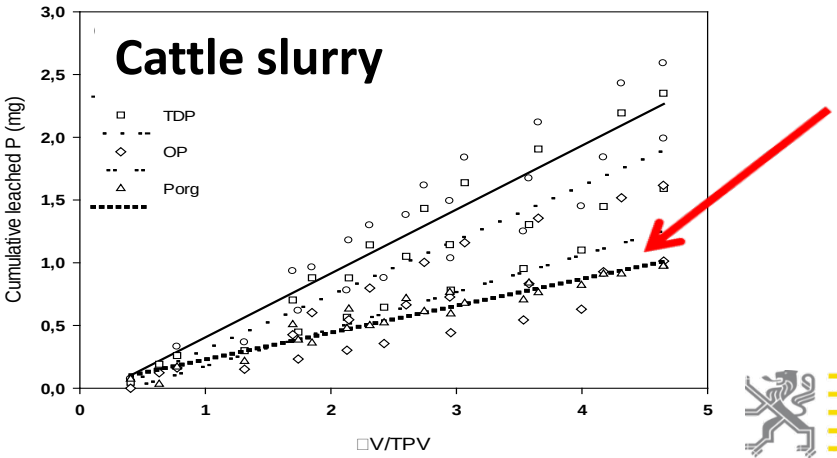
ILVO
Instituut voor Landbouw- en Visserijonderzoek

Potential P leaching

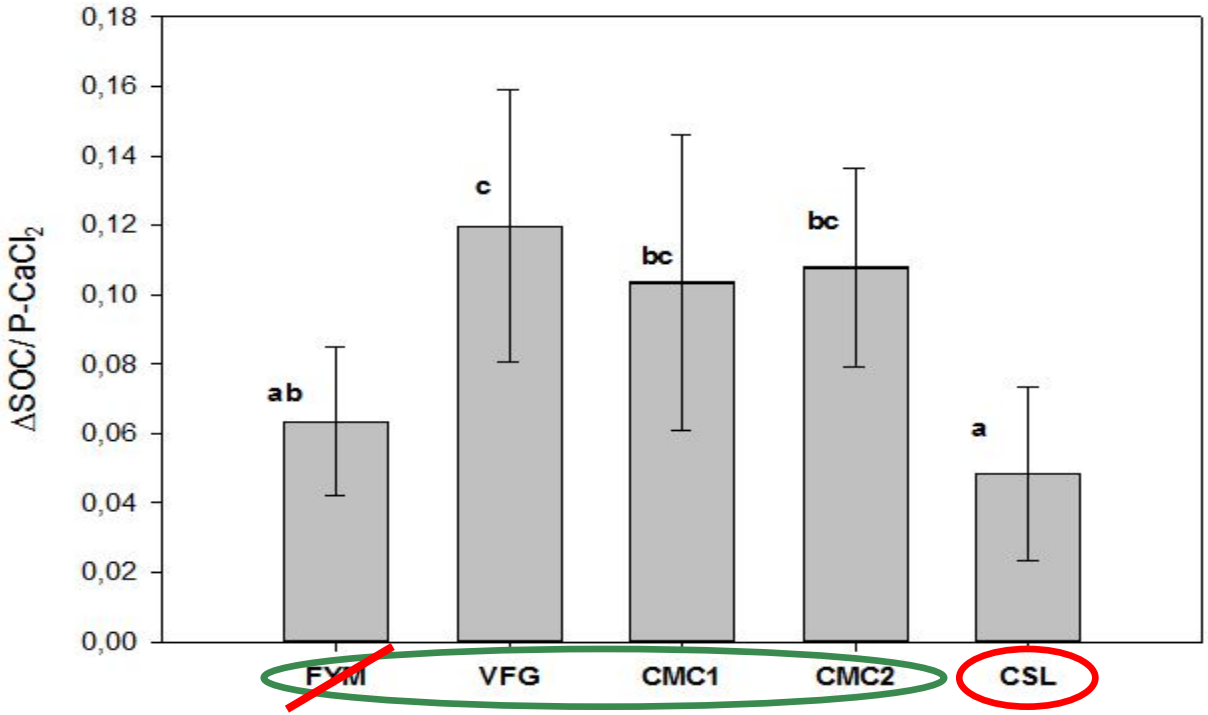








The field trial in one graph…



Discussion and conclusion

- Crop yield → influenced by soil quality (?)
- Farm yard manure
  - → increased P availability, but P export not changed
  - → increased potential P leaching
  - → increased TOC levels
  - → Composition or breakpoint?
- Compost
  - → P availability not changed
  - → potential P leaching not changed
  - → increased TOC levels
  - → gradually increases TOC without increasing potential P leaching

Acknowledgements

KATHOLIEKE UNIVERSITEIT LEUVEN

Prof. Dr. Ir. Merckx

UNIVERSITEIT GENT

Prof. Dr. Ir. Reheul

Ir. Cougnon

ILVO Instituut voor Landbouw- en Visserijonderzoek

Dr. Ir. Vandecasteele

Dr. Ir. Ruysschaert

Ir. D'Hose

Thank you for your attention

thijs.vandennest@ilvo.vlaanderen.be
www.ilvo.vlaanderen.be