Closing the nutrient cycle by using manure derivatives as synthetic fertilizer substitutes
a field experiment

5 decembre 2013

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Provincie West-Vlaanderen. Ondernemen het zit in ons.

This research is a cooperation of Inagro and Ugent

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Biomass for Energy

Investing in Opportunities
This project has received European Regional Development Funding through INTERREG IV B.
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Supporting the green economy

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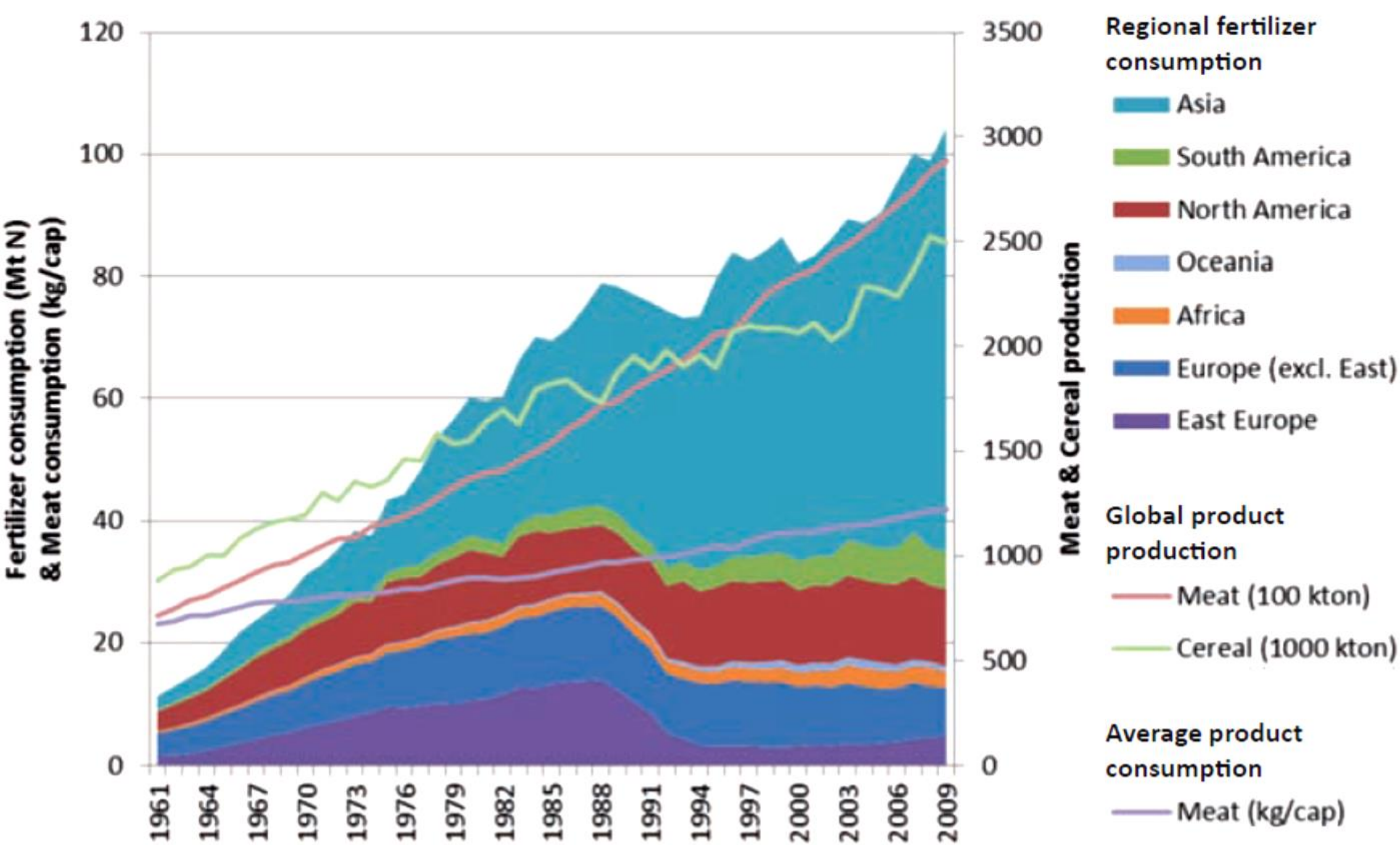
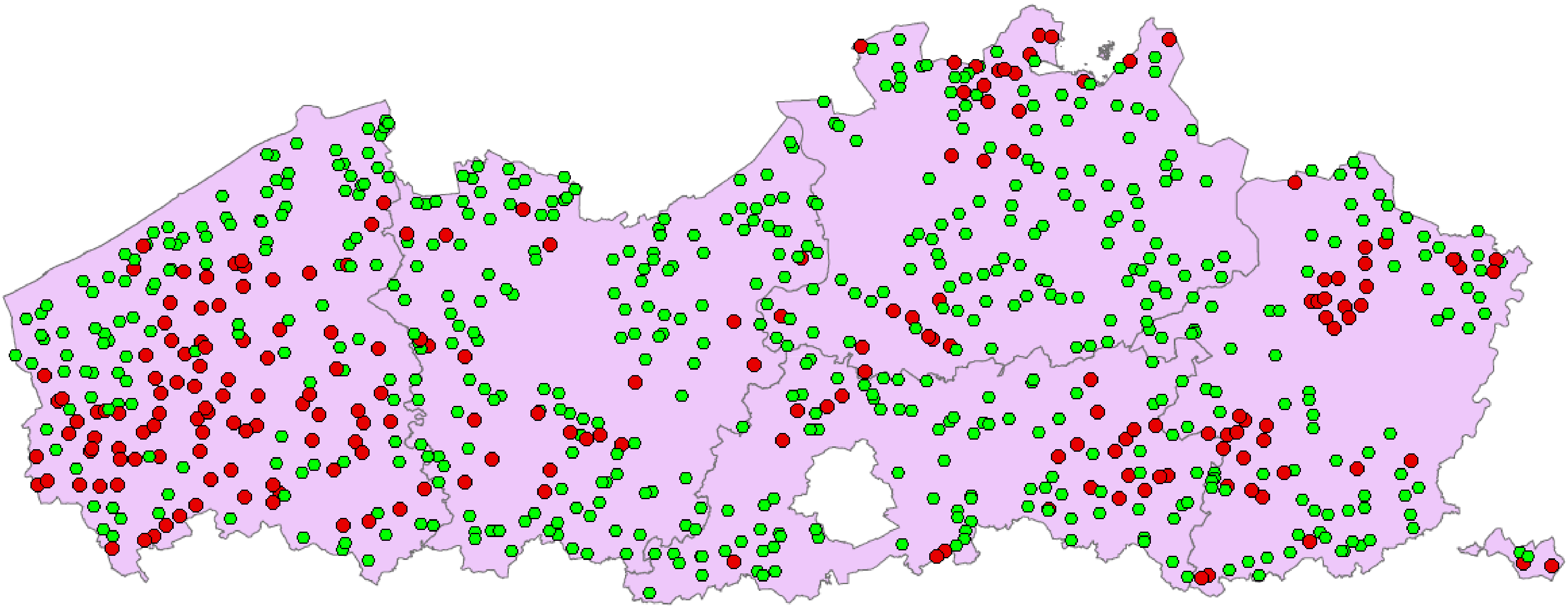
Problem statement

Global use of SYNTHETIC FERTILIZERS

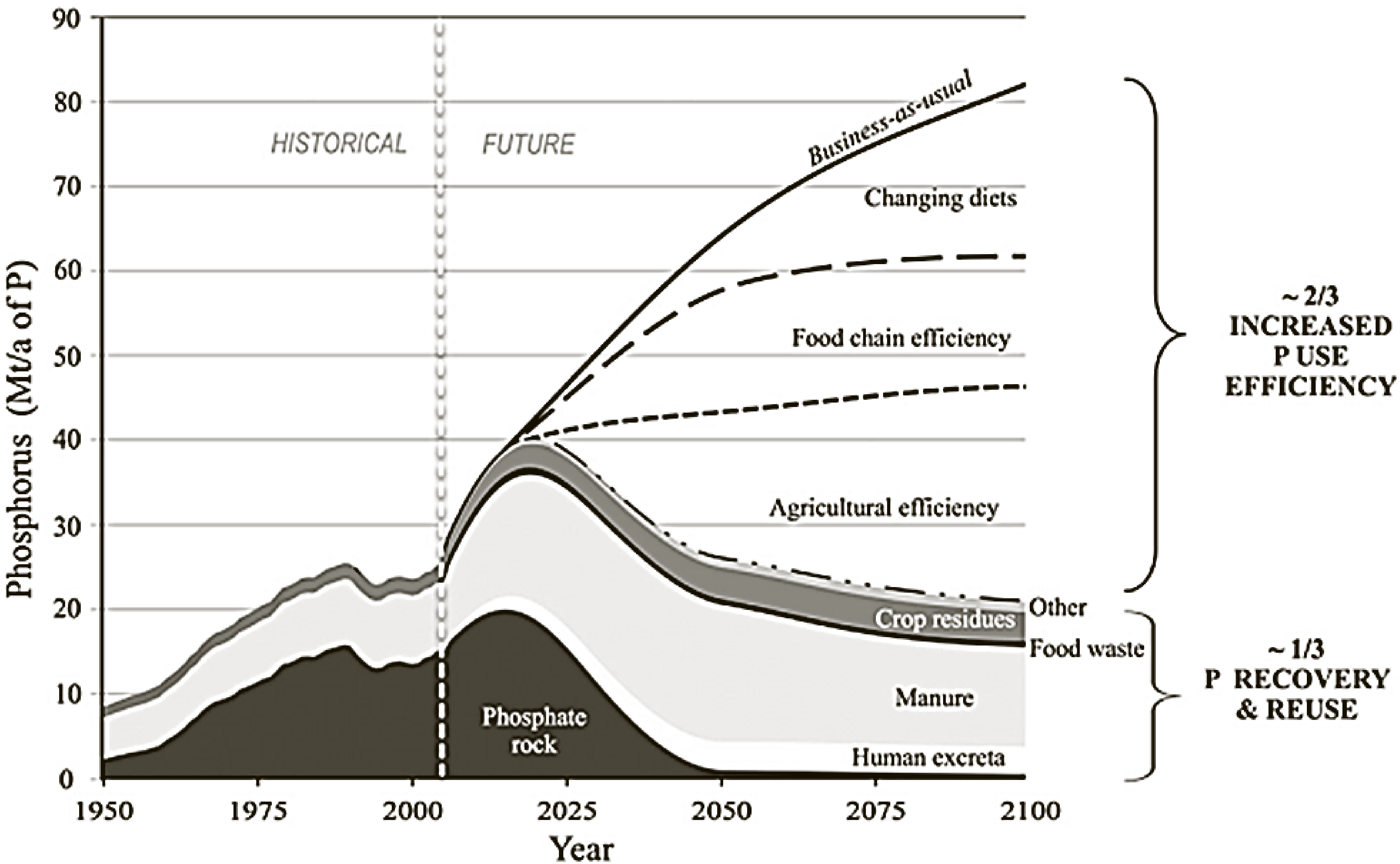


Nitrate residue

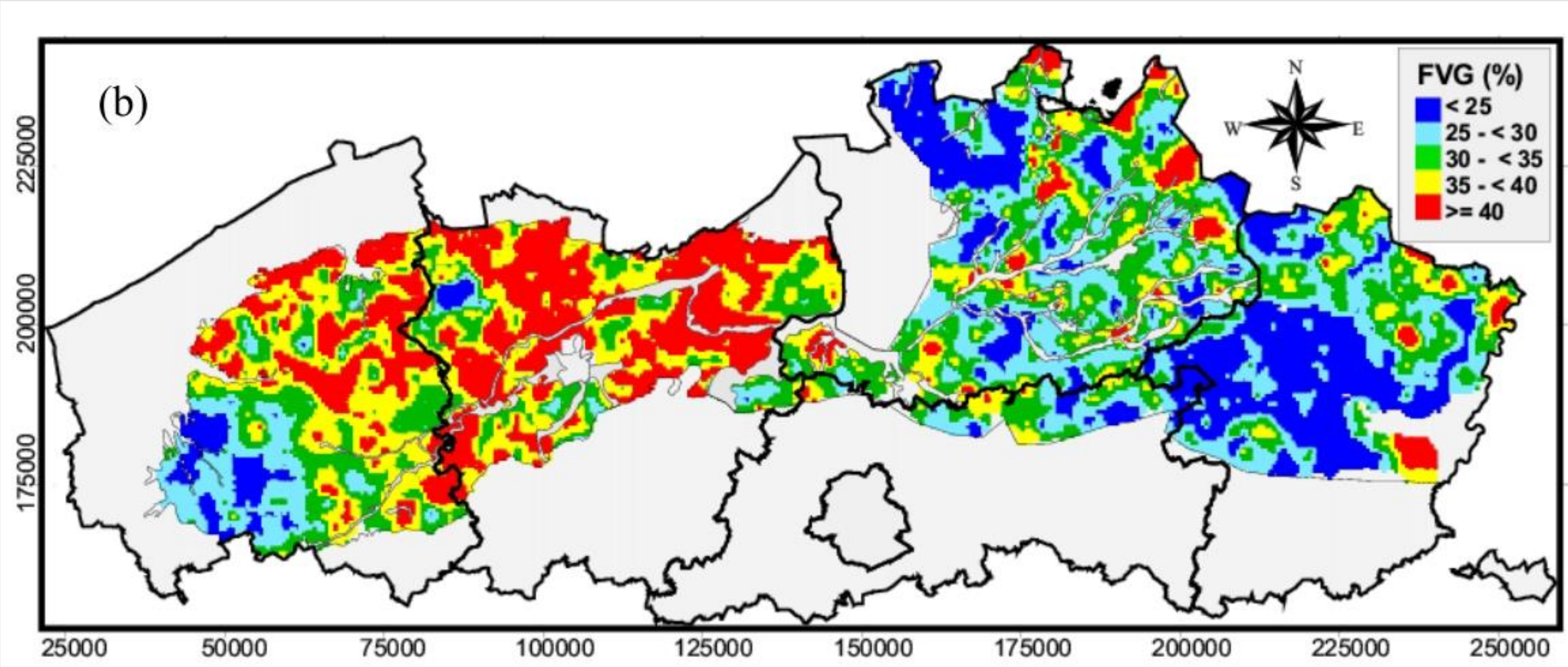
Low efficiency of nutrient application



Increasing NUTRIENT demand vs. Threathening DEPLETION



Phosphate saturated soil in Flanders



Stringent legislation: MAP IV

(Manure action plan)

	$P_2 0_5$-fertilizationsnorms (kg $P_2 0_5$/ha)				
	2009	2011-2012	2013-2014	2015-2016	2017-2018
Pastures: mowing	100	95	95	95	90
Pastures mowing+ grazing	100	90	90	90	90
Maize	85	80	80	75	70
Cereals	85	75	70	70	70
Sugar beet	80	75	65	55	55
Potatoes	85	75	65	55	55

Implication N-applicability on soil

Maize	2009	2011	2015	2017
Phosphate norm **(kg P_2O_5/ha)**	85	80	75	70
Pig Manure ton/ha	17	16	15	14
Tot N from manure	138	130	122	113
Effective N from manure	83	78	73	68
Sows slurry ton/ha	29	28	26	24
Tot N from manure	129	121	114	106
Effective N from manure	77	73	68	64

18% less N from manure!

Even more mineral N!

Even more skewed nutrient balance

A paradox exists…

Nutrient excesses in the environment from animal manure, digestate sludge, waste water, ashes, etc

Increasing demand for synthetic fertilizers

Environmental pollution

↓

Stringent fertilization levels

Nutrient depletion (P, K)

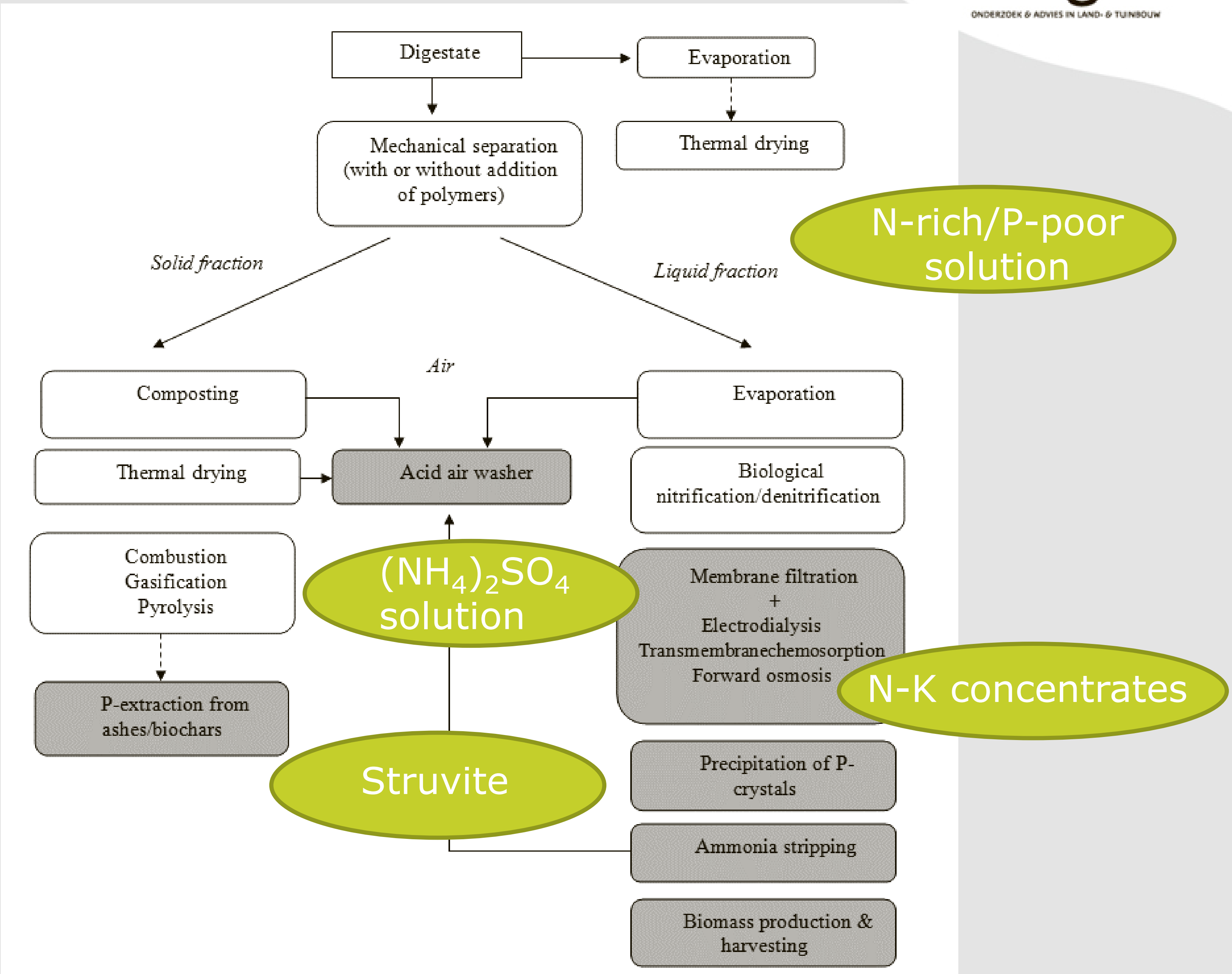
High energy use (N)

Price ↑, quality ↓

Solution

Cradle-to-cradle nutrient recycling

Manure and digestate processing



Technologies and products

Mechanical separation

- Liquid fraction: NK-solution, limited amount of C

Product	DS(%)	Total N (g/kg FM)	Effective N (g/kg FM)	P_2O_5 (g/kg FM)	K_2O (g/kg FM)
Liquid fraction	1,5	3,8	2,3	0,290	6,6
Pig Manure	7,6	6,9	4,1	4,4	4,9

- Ideal to apply more N and less P

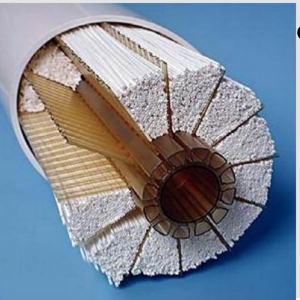
Technologies and products

Filtration after mechanical separation

- Membrane filtrates: NK-solution, very little C

Product	DS(%)	Total N (g/kg FM)	Effective N (g/kg FM)	P_2O_5 (g/kg FM)	K_2O (g/kg FM)
Membrane filtrates	0,3	7	6,4	0,2	7,6
Pig Manure	7,6	6,9	4,1	4,4	4,9

- Ideal to apply more N and less P
- Effectivity very close to mineral fertilizer



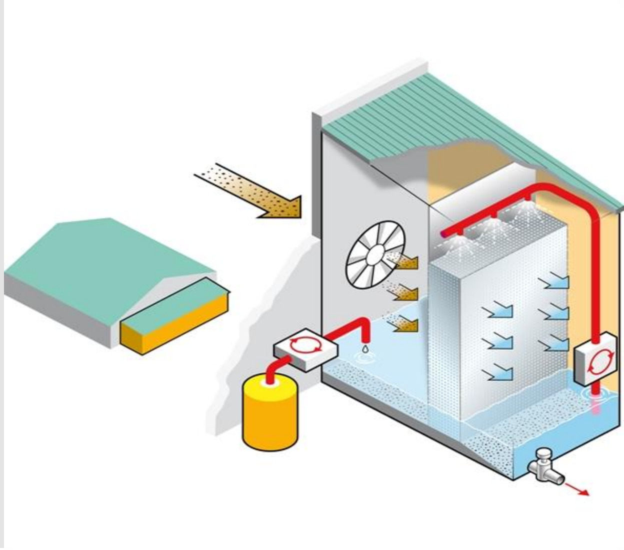
Technologies and products

Acid air washing

- Scrubber water: NH_4SO_4-solution

Product	Total N (g/kg FM)	Effective N (g/kg FM)	P_2O_5 (g/kg FM)	K_2O (g/kg FM)	SO_4 (g/kg FM)
Scrubber water	40-80	40-80	0	0	100-150

- N-S



Applied/ ha

	Artificial Start fertilizer E	Animal manure ton	Artificial fertilizer E	Air scrubber water liter	Liquid fraction digestate ton	Mineral concentr ates ton	K2O E
1	45	16	39				89
2	45	16	-	970			89
3	-	16	-	2125			89
8	-	14	-	600	19		189
9		14				10	169

Effective units- N

	Artificial Start fertilizer E	Animal manure ton	Artificial fertilizer E	Air scrubber water liter	Liquid fraction digestate ton	Mineral concentr ates ton
1	45	66	39			
2	45	66	-	38		
3	-	66	-	84		
8	-	58	-	23,7	68	
9		58				68

In practice

Field experiments

- 3 year field trial with maize
- 2 sites: sand and sandy-loam
- 4 replications

Field experiment Wingene, Flanders

Fertilizer application

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PLC-controlled injection (Boco-trance)

Physiochemical analysis

Biomass

- Yield
- Fresh & dry weight, N, P, K, Ca, Mg, Na, S, metals

Soil

- 0-30 cm: dry weight, pH-H_2O, pH-KCl, EC, N, NO_3, NH_4, P, K, Ca, Mg, Na, S, metals, Cl-, extractable nutrients
- 30-60 cm, 60-90 cm: dry weight, NO_3

Eight fertilization scenarios

Dosage of effective N and K_2O based on fertilizer analysis and soil advice (135/150 kg effective N/ha, 80 kg P_2O_5/ha, 180/250 kg K_2O/ha)

	Year	Synthetic Start N[a]	Synthetic N[a]	Air scrubber water	Animal manure	Digestate mixture[b]	Liquid fraction digestate	Synthetic K_2O[c]	Total P_2O_5
		kg N/ha	kg N/ha	kg N/ha	kg N/ha	kg N/ha	kg N/ha	kg K_2O/ha	kg P_2O_5/ha
1	1								
	2								
2	1	25		29	96			78	80
	2								
3	1								
	2			60	75			213	80
4	1	25	18			107		29	80
	2								
5	1								
	2								
6	1								
	2			33		102		46	61
7	1								
	2								
8	1								
	2								

Scenario 1: Reference

Scenarios 2–3: Substitution of synthetic fertilizer by air scrubber waste water

Scenarios 4–6: Anaerobic digestion of animal manure and use of digestate as fertilizer, with and without the substitution of synthetic fertilizer by air scrubber waste water

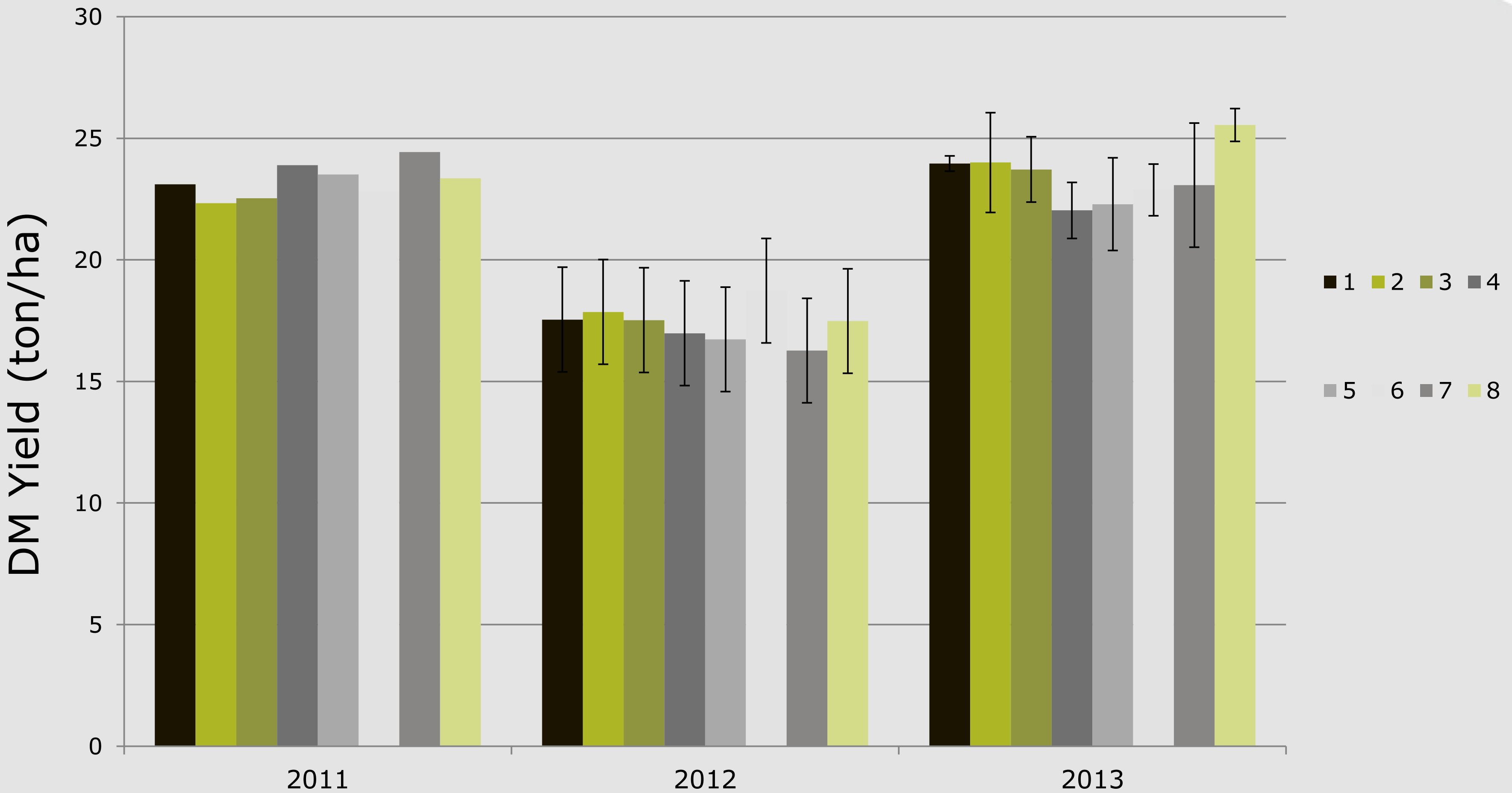
Scenarios 7–8: Use of the liquid fraction of digestate as P-poor fertilizer, with and without the substitution of synthetic fertilizer by air scrubber waste water

[a] ammoniumnitrate (27% N), [b] Mixture (φ = 0.5) of digestate and liquid fraction of digestate
[c] patentkali (30% K_2O, 10% Mg)

Results

Similar growth pattern

Dry weight



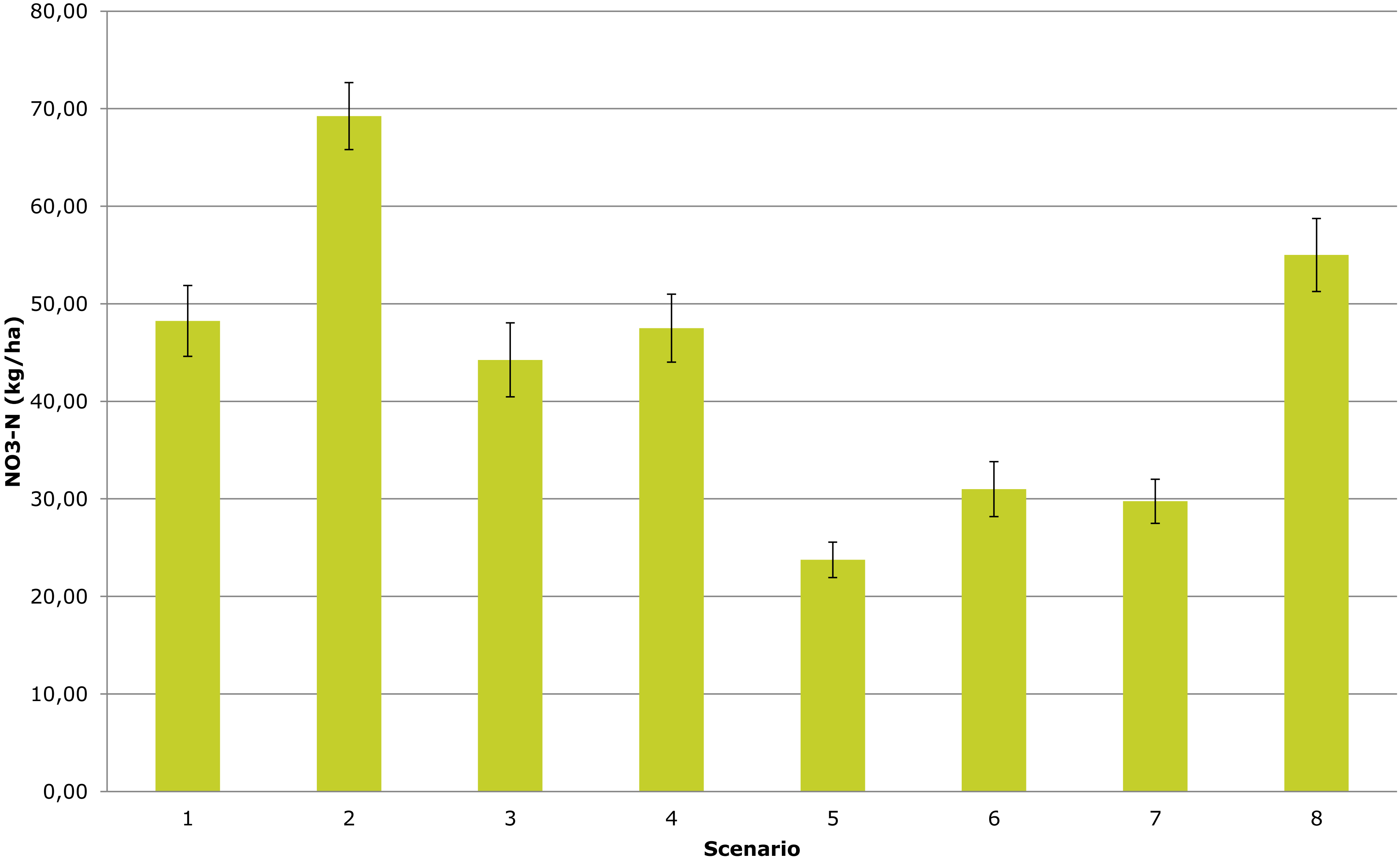
Biomass production

No significant differences in total dry matter

Only minor differences in DM%

!Object 1 isn’t best!

Nitrate residue



Soil quality

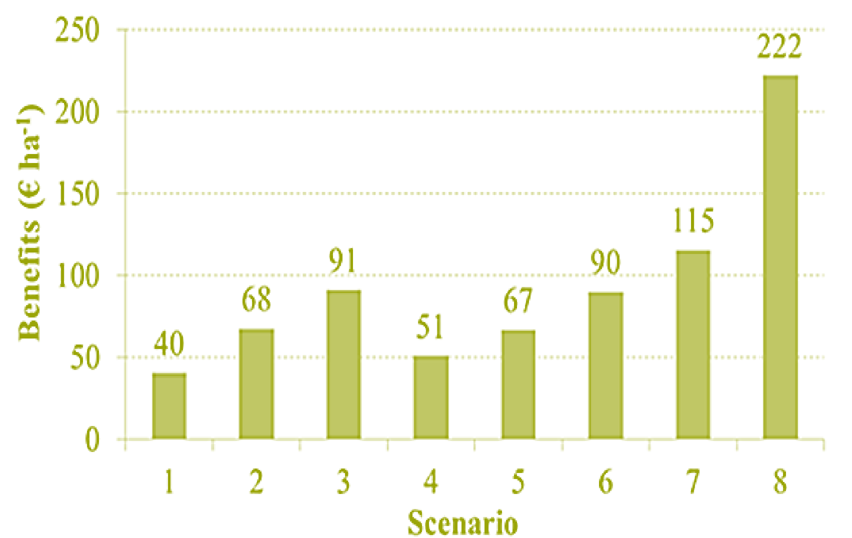
No problem with nitrate residue

No significant effect on soil EC, pH-H_2O, pH-KCl, sodium adsorption ratio, S-content and heavy metal accumulation

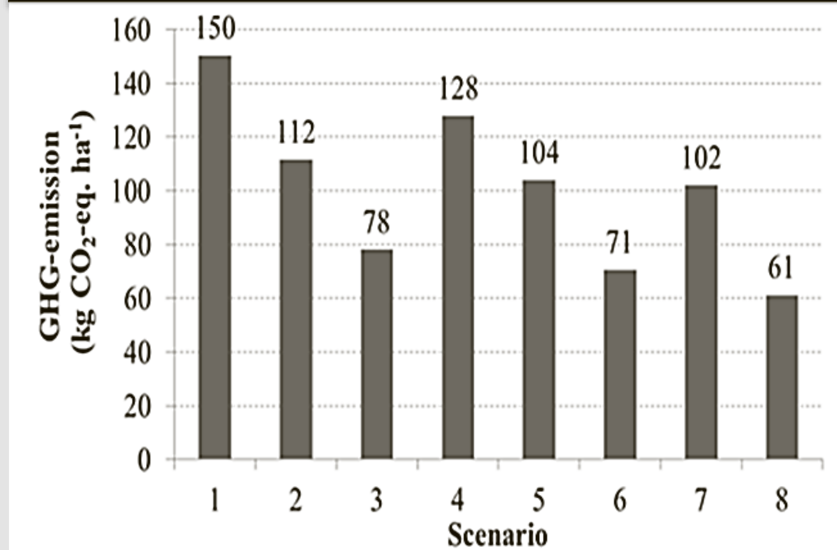
Significantly more organic carbon in scenario 4-8

Economical and ecological evaluation (2011)

- Benefits
- (euro ha^{-1})



Greenhouse gas emission
(kg CO_2 eq. ha^{-1})



Sc 8: Use of LF digestate and complete elimination of synthetic fertilizers

Conclusions and perspectives

Recycling of nutrients can

- maintain biomass production
- create sustainable substitutes for synthetic fertilizers with high nutrient efficiencies
- result in economical and ecological benefits

Challenges

- Standardisation of products
- Low nutrient concentrations
- Means of application
- EU-legislation

Questions?

Thank you for your attention