

Fourth International Symposium On Energy From Biomass And Waste, San Servolo, Venice (Italy) , 12-15 November 2012

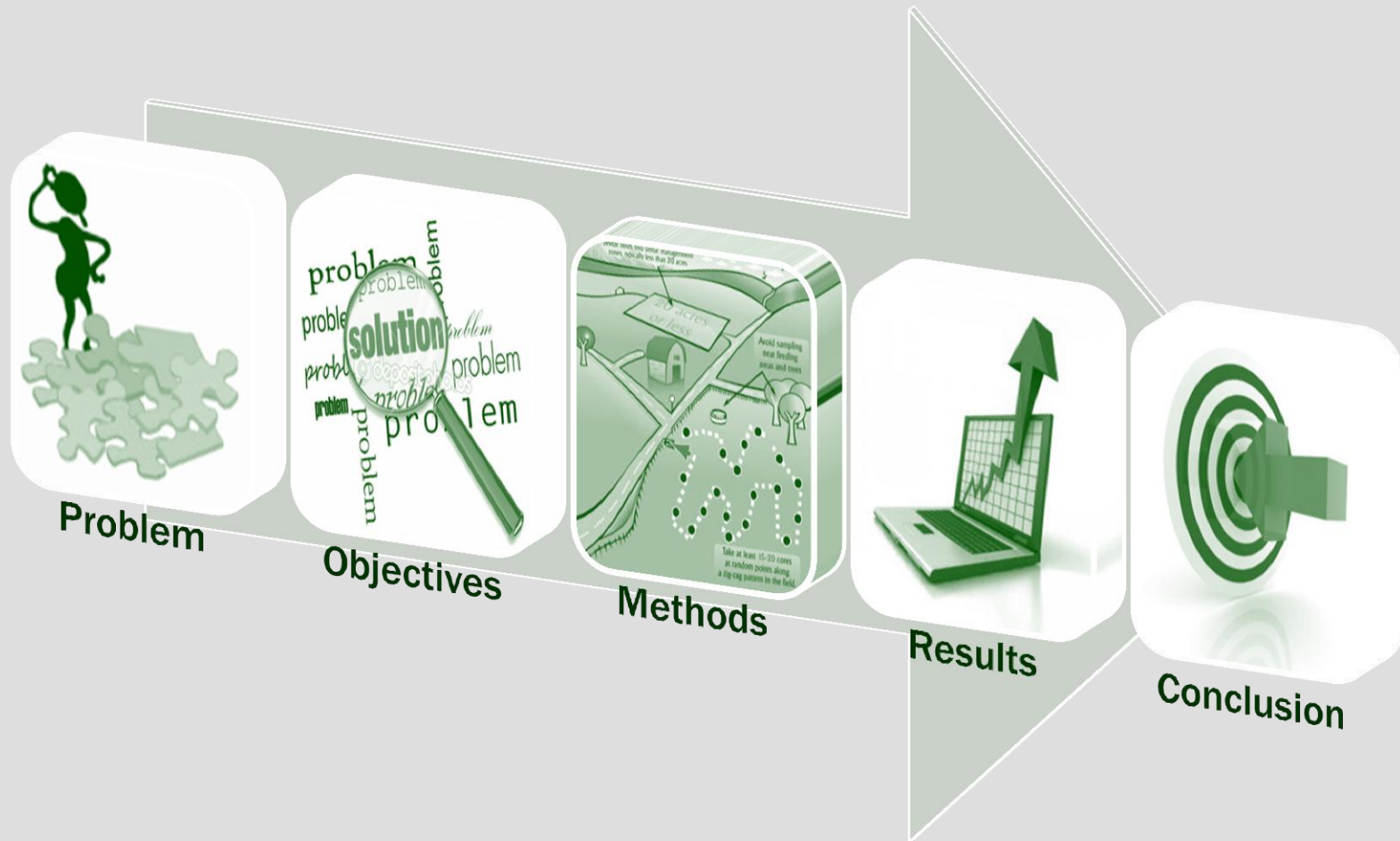
**NUTRIENT RECYCLING FROM BIO-DIGESTION
WASTE AS SYNTHETIC FERTILIZER SUBSTITUTES:
A FIELD EXPERIMENT**

Céline Vaneekhaute, Erik Meers, Greet Ghekiere,
Frederik Accoe, Evi Michels, Filip M.G. Tack

*Laboratory of Analytical and Applied Ecochemistry,
Faculty of Bioscience Engineering,
Ghent University, Belgium
Celine.Vaneekhaute@ugent.be*



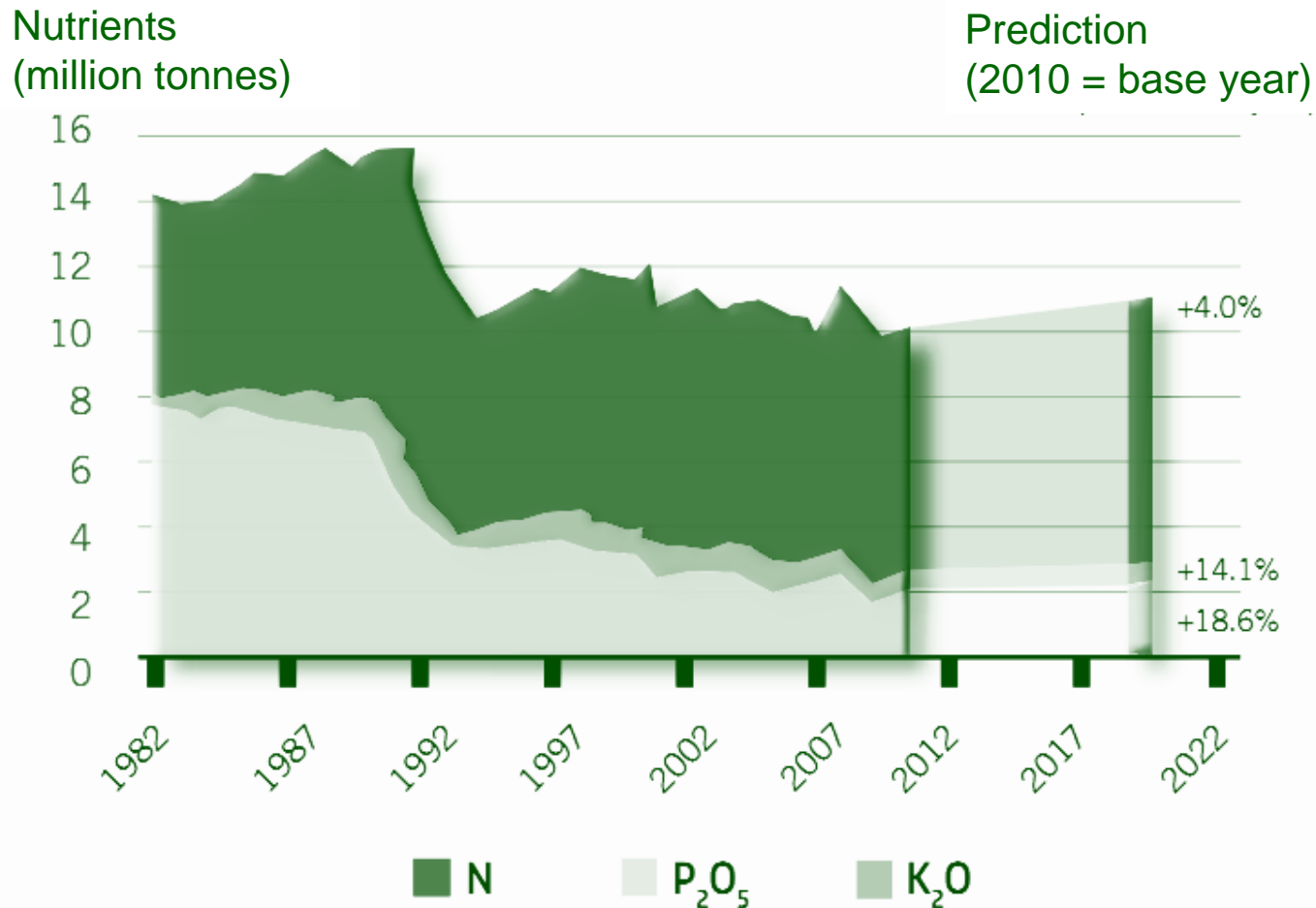
OUTLINE



PROBLEM STATEMENT



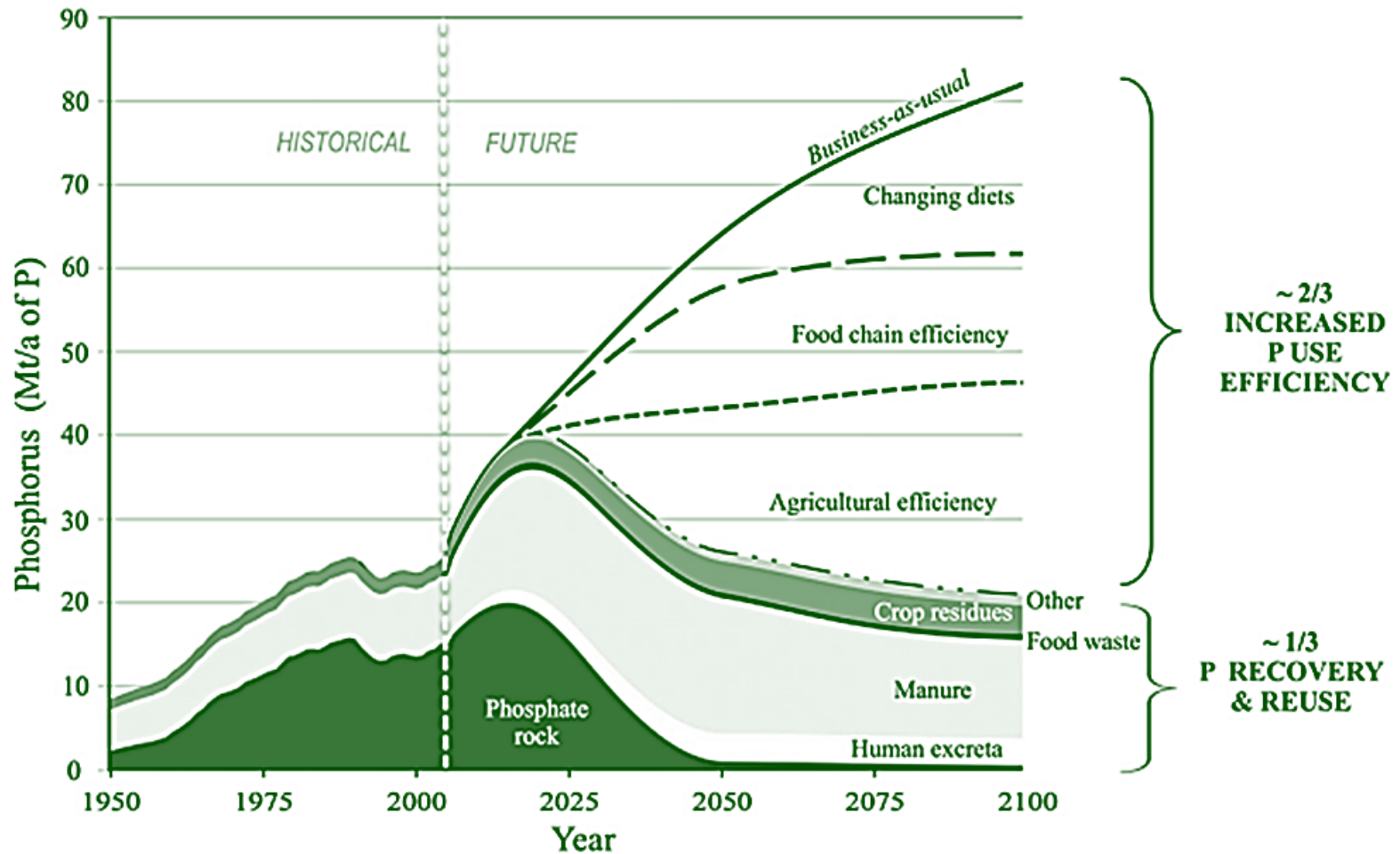
SYNTHETIC FERTILIZER USE IN EU27



ENERGY USE AND COSTS FOR SYNTHETIC FERTILIZERS

		N	P ₂ O ₅	K ₂ O	Unit	Reference
ENERGY	Production	70	7.7	6.4	GJ/ton	Gellings & Parmenter (2004)
	Packing	2.6	2.6	1.8	GJ/ton	Gellings & Parmenter (2004)
	Transport	4.5	5.7	4.6	GJ/ton	Gellings & Parmenter (2004)
	Application	1.6	1.5	1.0	GJ/ton	Gellings & Parmenter (2004)
	Total	78	18	14	GJ/ton	Gellings & Parmenter (2004)
COSTS	Total	1.037	0.956	0.625	euro/kg	Aveve (2011)

NUTRIENT USE VS. DEPLETION



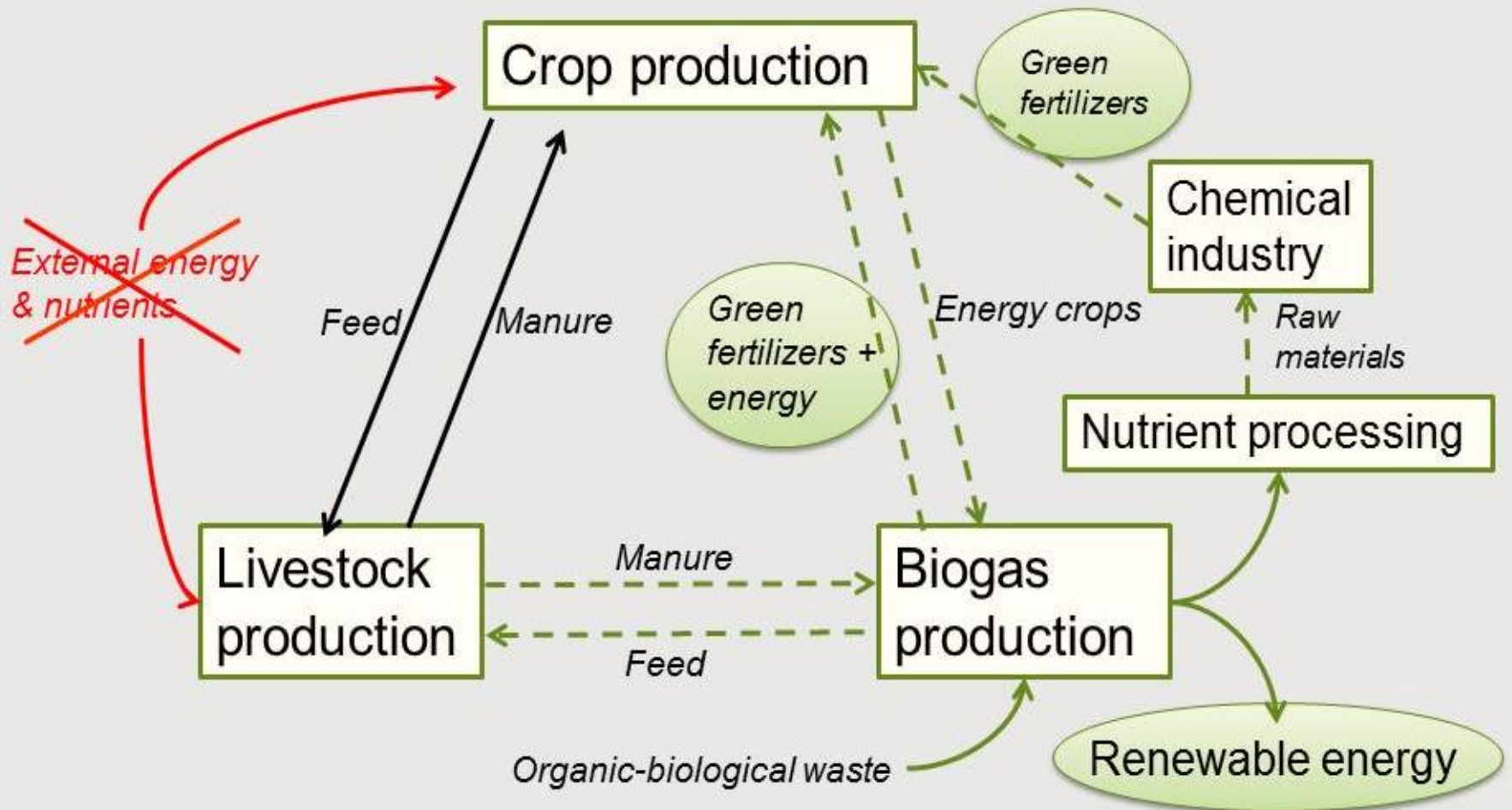


**NEED FOR A SUSTAINABLE
RESOURCE MANAGEMENT !**

OBJECTIVES



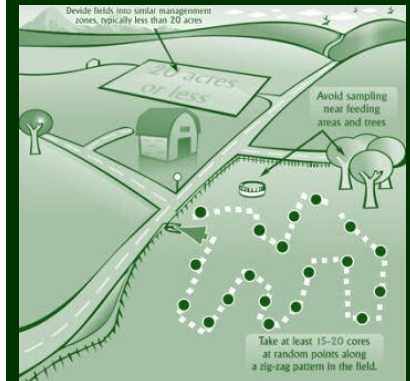
CRADLE-TO-CRADLE NUTRIENT RECYCLING



SPECIFIC GOALS

- 1. Recuperation of nutrients from bio-digestion waste as green fertilizers**
- 2. Evaluation of the impact on biomass yield and soil quality**
- 3. Economic and ecological analysis**

METHODS



FIELD EXPERIMENT WINGENE, FLANDERS



EIGHT FERTILIZATION SCENARIOS

Dosage of effective N and K₂O based on fertilizer analysis and soil advice
(135 kg effective N/ha, 80 kg P₂O₅/ha, 180 kg K₂O/ha)

	Synthetic Start N ^a	Synthetic N ^a	Air scrubber water	Animal manure	Digestate mixture ^b	LF ^c digestate	Synthetic K ₂ O ^d
	kg N/ha	kg N/ha	kg N/ha	kg N/ha	kg N/ha	kg N/ha	kg K ₂ O/ha
1	25	29	0	96	0	0	78
2	25	0	29	96	0	0	78
3	0	0	54	96	0	0	78
4	25	18	0	0	107	0	29
5	25	0	18	0	107	0	29
6	0	0	43	0	107	0	29
7	25	0	0	84	0	35	33
8	0	0	0	78	0	59	0

^a ammoniumnitrate (27% N), ^b Mixture ($\varphi = 0.5$) of digestate and liquid fraction of digestate

^c LF = Liquid Fraction, ^d patentkali (30% K₂O, 10% Mg)

FOUR REPLICATIONS

Strip of land			
obj 7	obj 8	obj 2	obj 5
obj 1	obj 4	obj 3	obj 4
obj 2	obj 5	obj 1	obj 6
Strip of land			
obj 3	obj 6	obj 7	obj 8
obj 2	obj 4	obj 7	obj 8
Strip of land			
obj 1	obj 5	obj 3	obj 6
obj 3	obj 6	obj 2	obj 5
obj 7	obj 8	obj 1	obj 4
Strip of land			

FERTILIZER APPLICATION



Boco-trance

SAMPLING OF PLANT AND SOIL



July, September, October (harvest), November (nitrate residue)

PHYSICO-CHEMICAL ANALYSIS

PLANT

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

SOIL

- 0-30 cm: dry weight, pH-H₂O, pH-KCl, EC, N, NO₃, NH₄, P, K, Ca, Mg, Na, S, metals, Cl⁻, extractable nutrients
- 30-60 cm, 60-90 cm: dry weight, NO₃

RESULTS





VISUAL

June 4 2011
Simultaneous
growth



VISUAL

June 4 2011

Drought
symptoms



VISUAL

June 19 2011

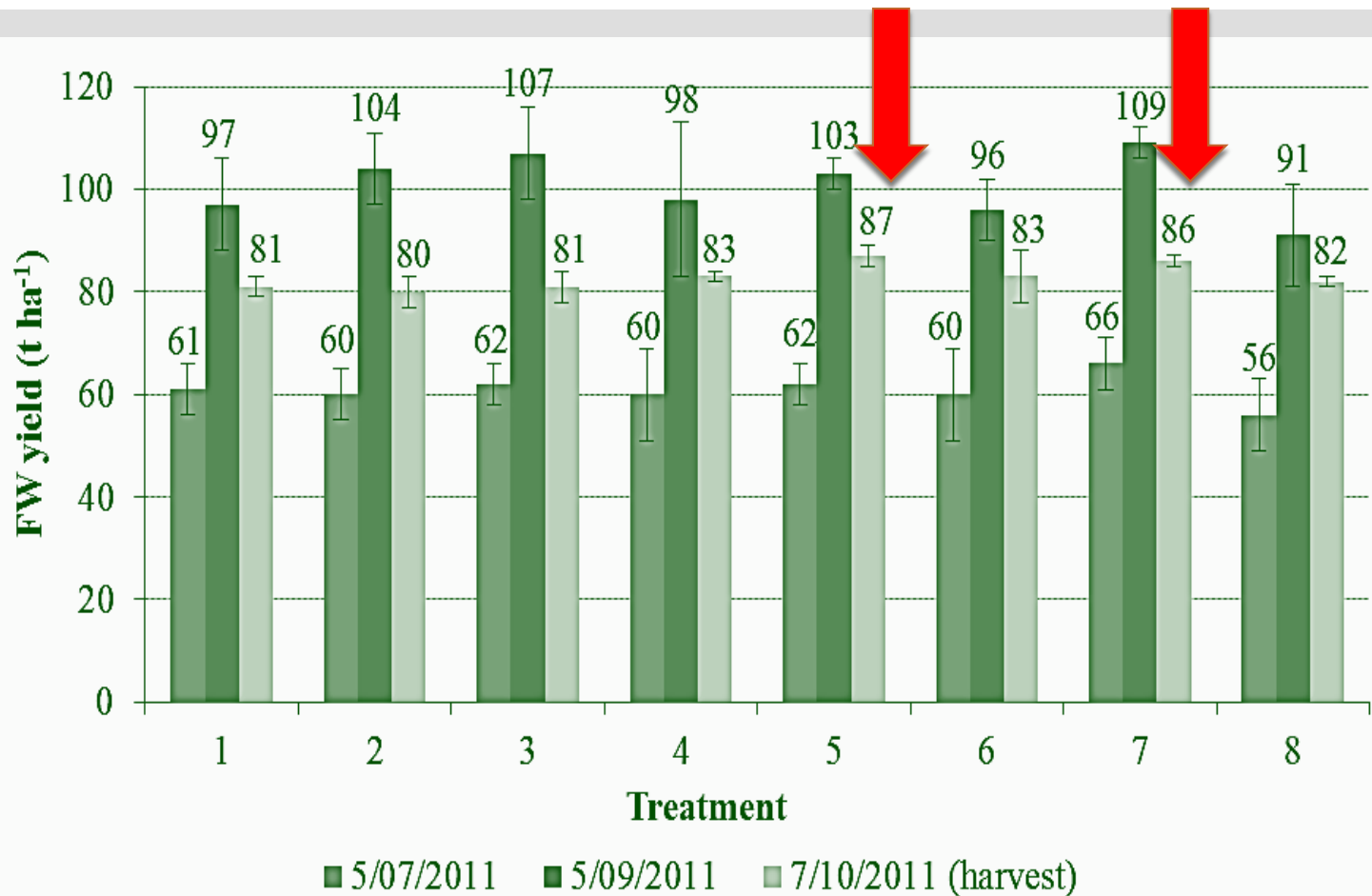
Plant \pm 30 cm



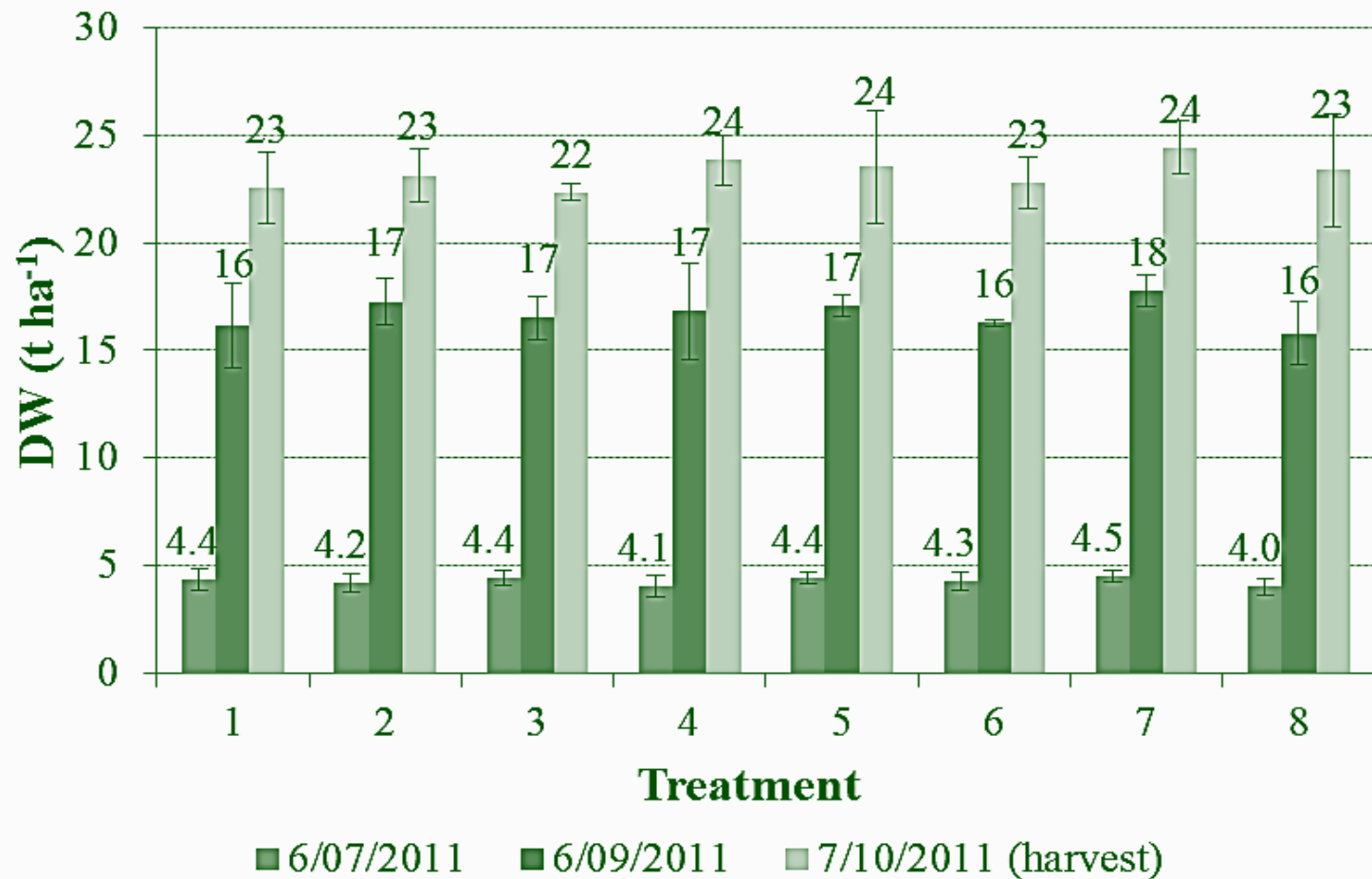
VISUAL

Aug 20 2011
Plant ± 3.60 m
Cob formation

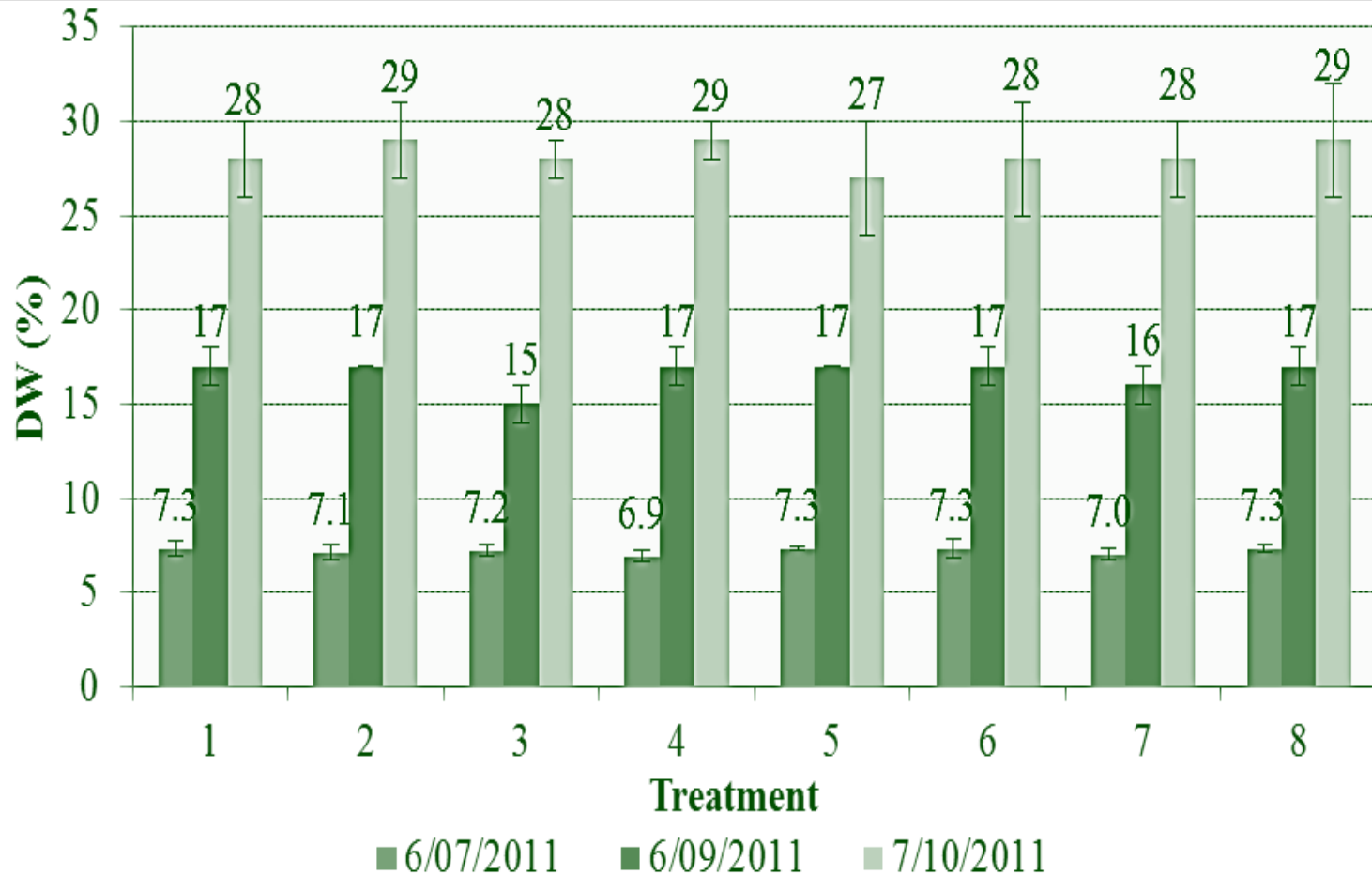
FRESH WEIGHT BIOMASS YIELD



DRY WEIGHT BIOMASS YIELD



DRY WEIGHT CONTENT



BIOGAS POTENTIAL

Scenario	DW (%)	Residence time (d)	Biogas (Nm ³ ton ⁻¹ FW)	CH ₄ (m ³ ha ⁻¹)	Energy (GJ ha ⁻¹)	Electricity (MWh _{el} ha ⁻¹)	Heat (MWh _{th} ha ⁻¹)
1	28	42	136	6309 ± 156	200 ± 5	22 ± 1	24 ± 1
2	29	34	143	6536 ± 245	207 ± 8	23 ± 1	25 ± 1
3	28	36	135	6260 ± 232	198 ± 7	22 ± 1	24 ± 1
4	29	39	140	6659 ± 80	211 ± 3	23 ± 0	26 ± 0
5	27	37	131	6536 ± 150	207 ± 5	23 ± 1	25 ± 1
6	28	42	135	6383 ± 384	202 ± 12	22 ± 1	25 ± 1
7	28	41	139	6818 ± 79	216 ± 3	24 ± 0	26 ± 0
8	29	37	140	6558 ± 80	208 ± 3	23 ± 0	25 ± 0

NITROGEN BALANCE

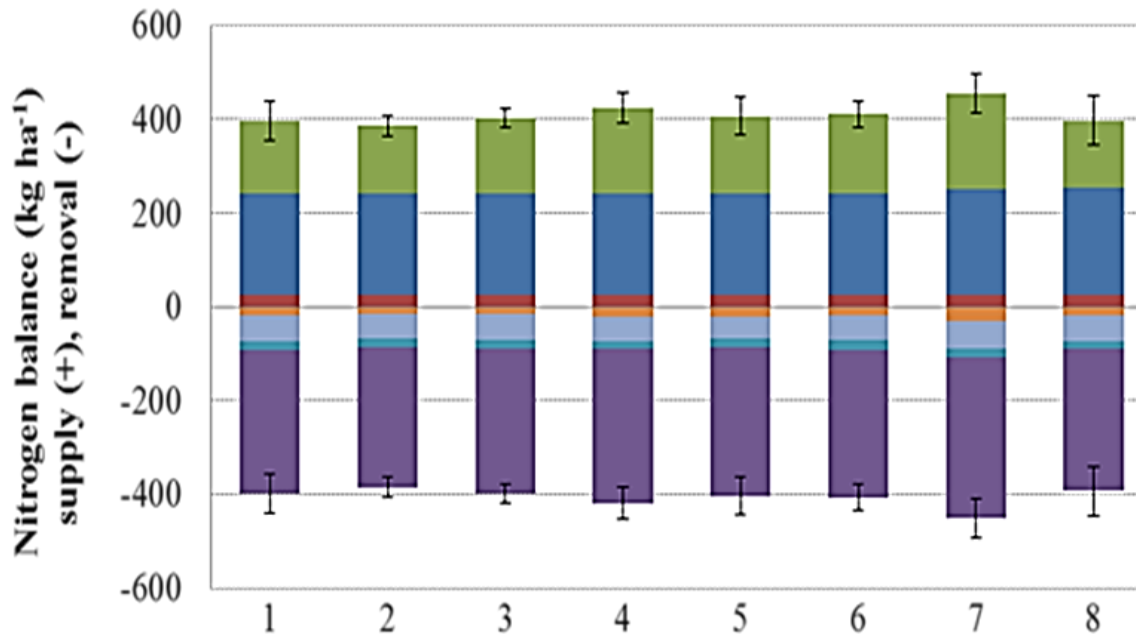
Modeled with NDICEA

No significant differences ($\alpha=0.5$)

Demand > supply by manure application

Nitrate leaching lower than reference, except scenario 7

Nitrate residue high in scenario 1,2,3,5 (weather conditions)



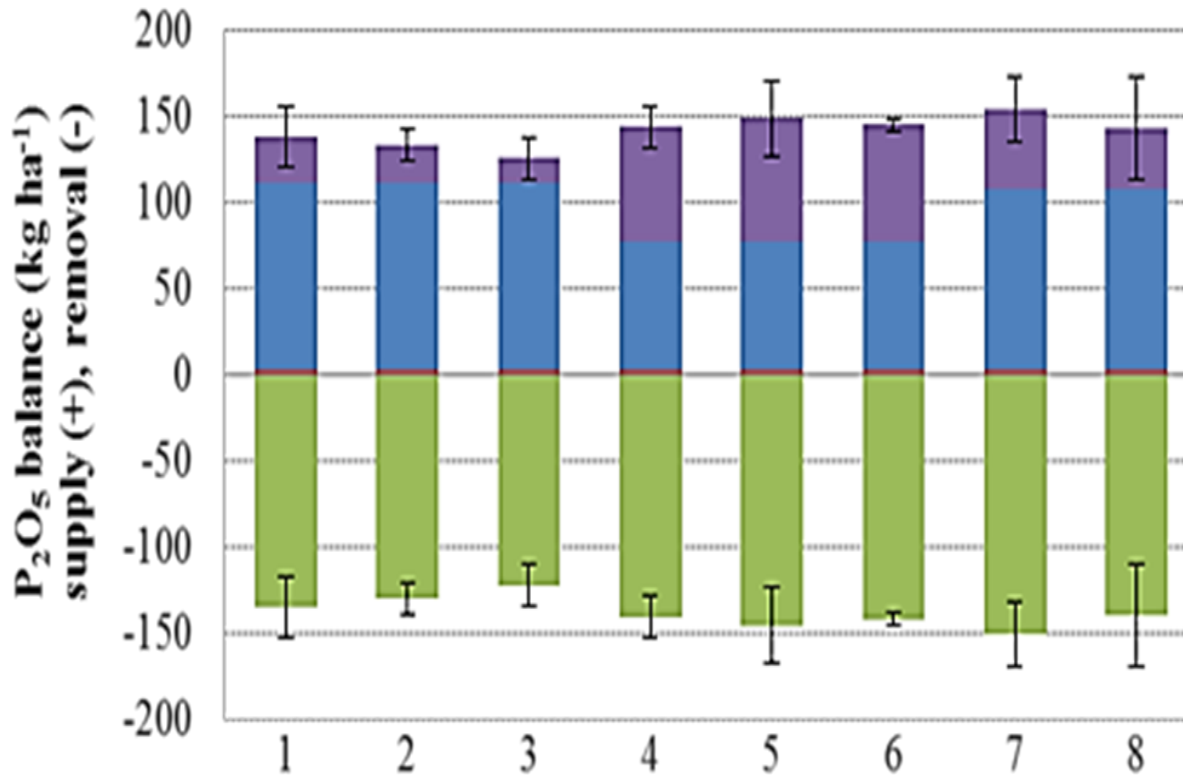
Decomposition organic matter	156	145	162	182	165	169	206	142
Manure supply	216	216	216	217	217	217	225	230
Deposition	25	25	25	25	25	25	25	25
Removal with products	-306	-301	-309	-329	-317	-313	-344	-303
Volatilization	-17	-18	-19	-16	-19	-24	-17	-17
Leaching/denitrification subsoil	-58	-53	-56	-53	-47	-52	-60	-55
Denitrification	-17	-14	-16	-21	-21	-18	-31	-19

PHOSPHATE BALANCE

Demand > supply in all scenarios

Supply > standard in scenario 1,2,3,7,8 (manure variability)

Uptake soil P higher in scenario 4,5,6
=> Higher soil nutrient use efficiency ?



■ Calculated deficit	27	22	15	67	72	68	46	35
■ Manure supply	108	108	108	74	74	74	105	105
■ Deposition	3	3	3	3	3	3	3	3
■ Removal with products	-135	-130	-123	-141	-146	-142	-151	-140

EIGHT FERTILIZATION SCENARIOS

Dosage of effective N and K₂O based on fertilizer analysis and soil advice (135 kg effective N/ha, 80 kg P₂O₅/ha, 180 kg K₂O/ha)

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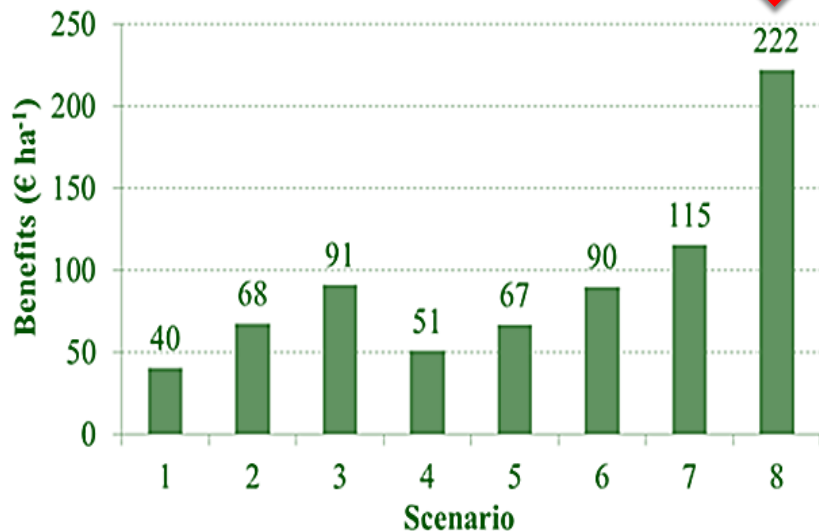
SOIL QUALITY

- No significant effect on soil EC, pH-H₂O, pH-KCl, Sodium Adsorption Ratio
- Significantly more organic carbon in scenario 4-8
- High Cu-concentration in all scenarios (historical)

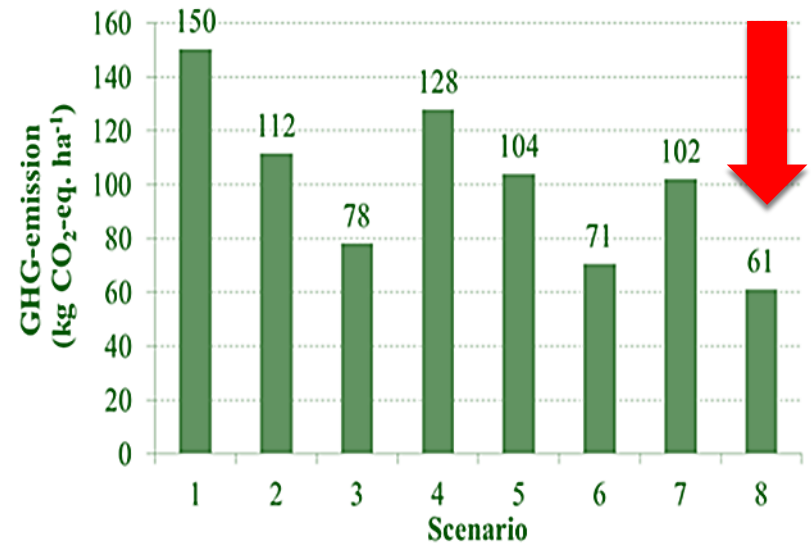


ECONOMIC AND ECOLOGICAL EVALUATION

**Benefits
(euro/ha)**



**Greenhouse gas emission
(kg CO₂ eq./ha)**



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CONCLUSIONS AND PERSPECTIVES



CONCLUSIONS

Recycling of nutrients from bio-digestion waste derivatives in agriculture can:

- **create sustainable substitutes for synthetic fertilizers**
- **increase the soil nutrient use efficiency**
- **result in significant economic and ecological benefits**

PERSPECTIVES

- Stimulation of green fertilizer use in European legislation
- Validation of results in the longer term and for different soil types (2012-2013)



**THANK YOU FOR THE
ATTENTION**

QUESTIONS ?

