Modeling the effect of soil structure on water flow and isoproturon dynamics in an agricultural field receiving repeated urban waste compost application

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Sous les tutelles

Tillage affects soil structure

Tillage affects soil structure

The « profil cultural » (Manichon, 1982)

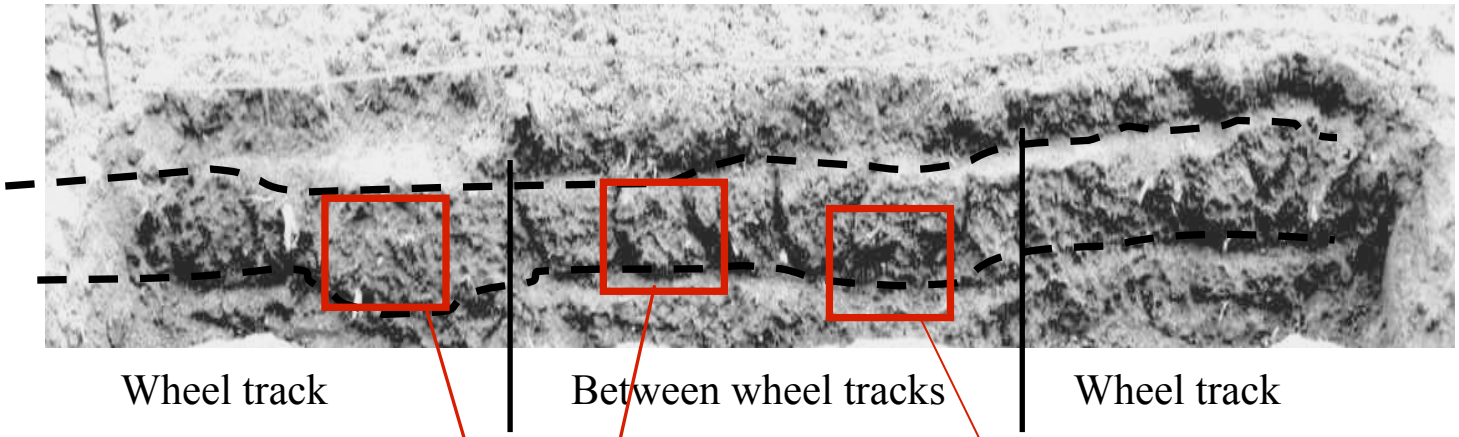
Compartments

Seed bed

10 cm

Ploughed layer

Untilled soil

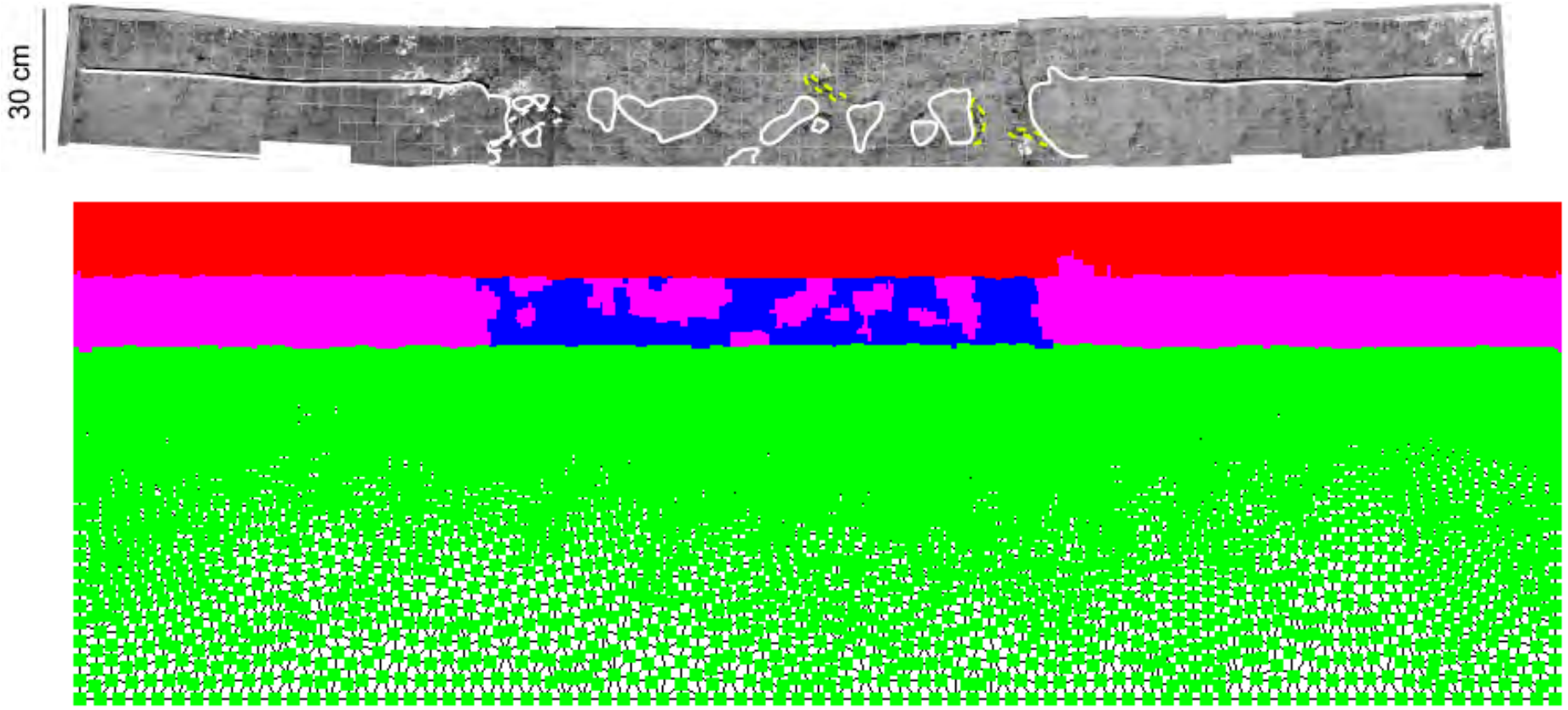


Internal structure of the compartment

Compacted soil Δ

Non-compacted soil Γ

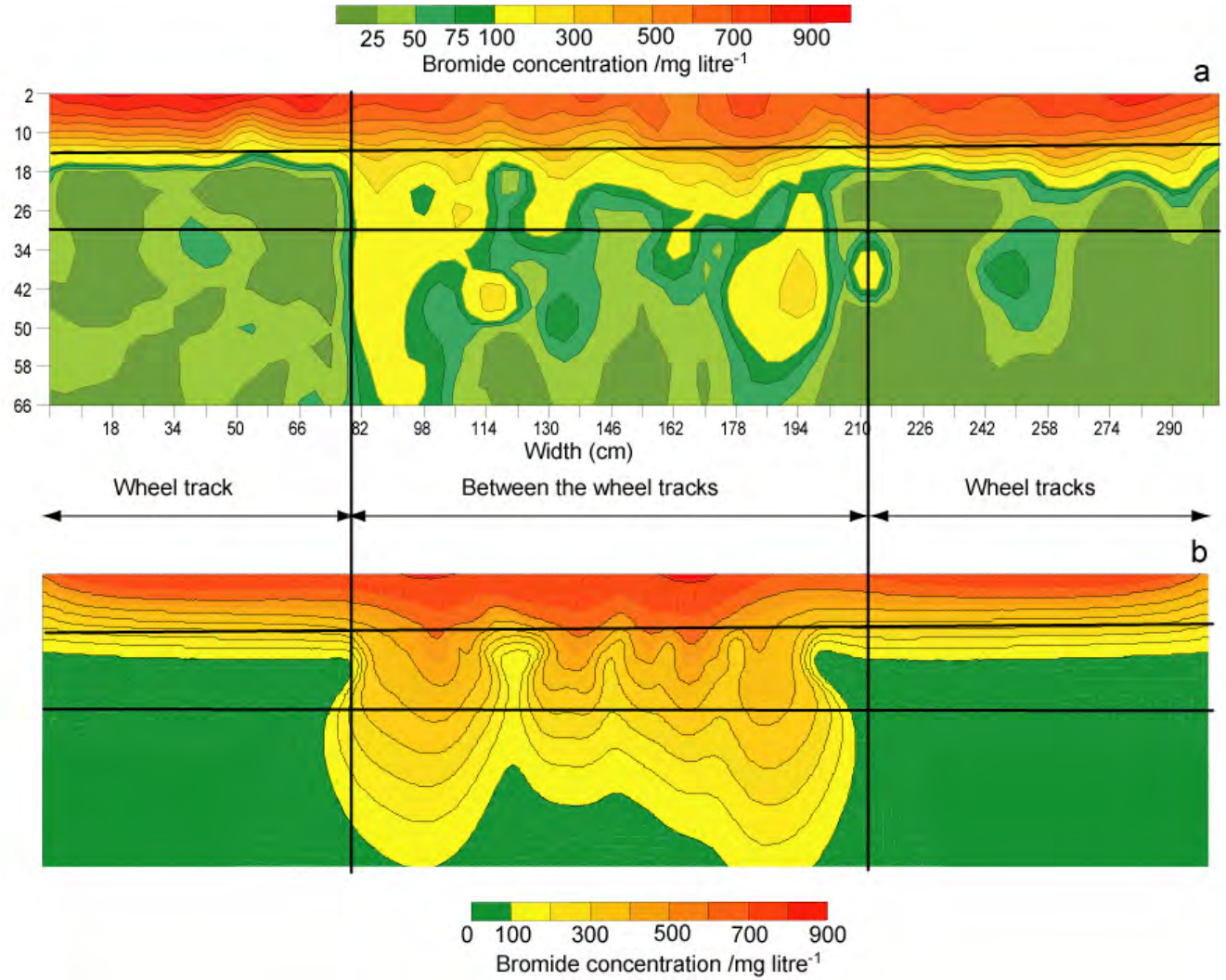
Tillage affects soil structure



Tillage affects soil structure

Measured

Simulated

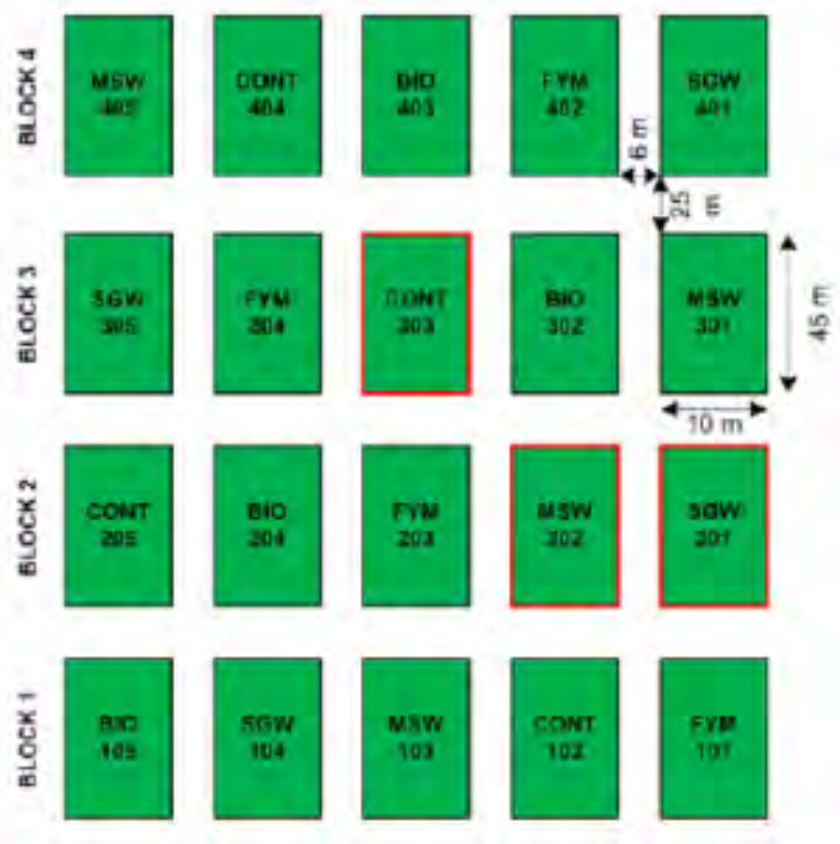


(Coquet et al., 2005)

Tillage affects soil structure

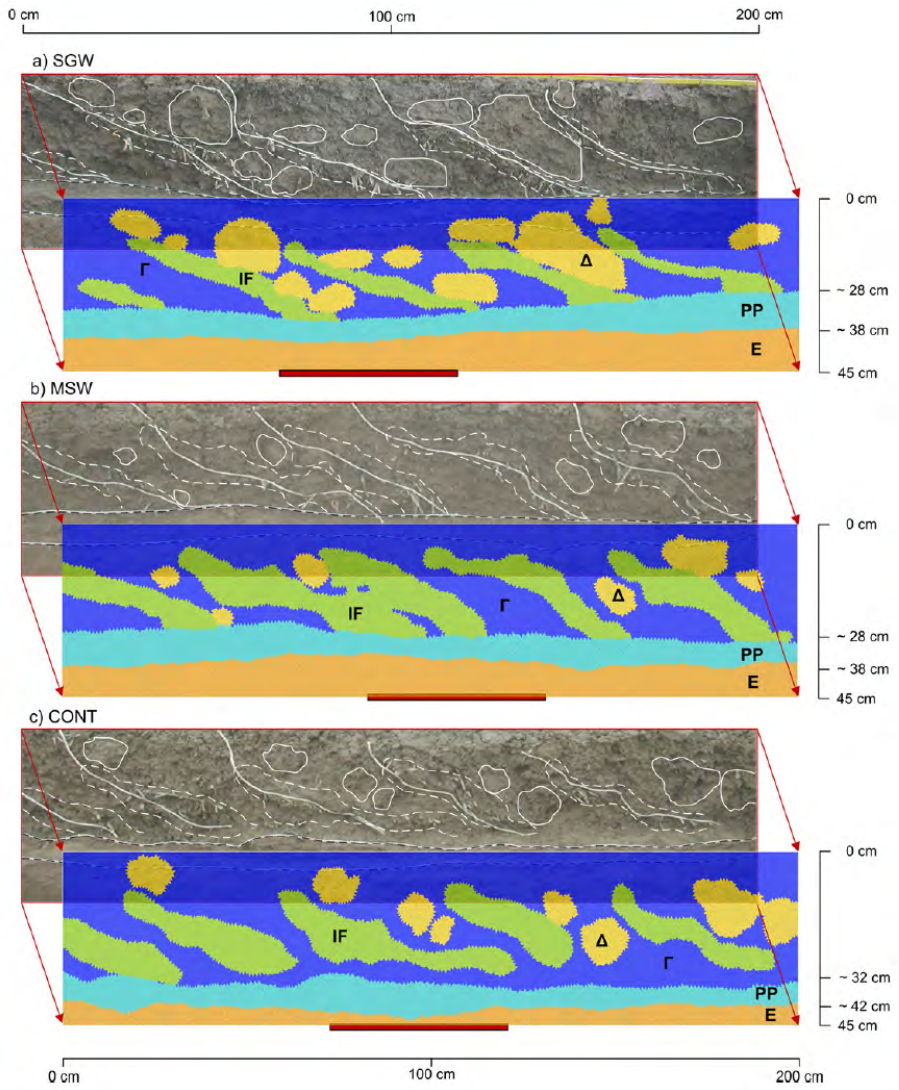
- *Does it affect pesticide fate and transport ?*

The Qualiagro field trial



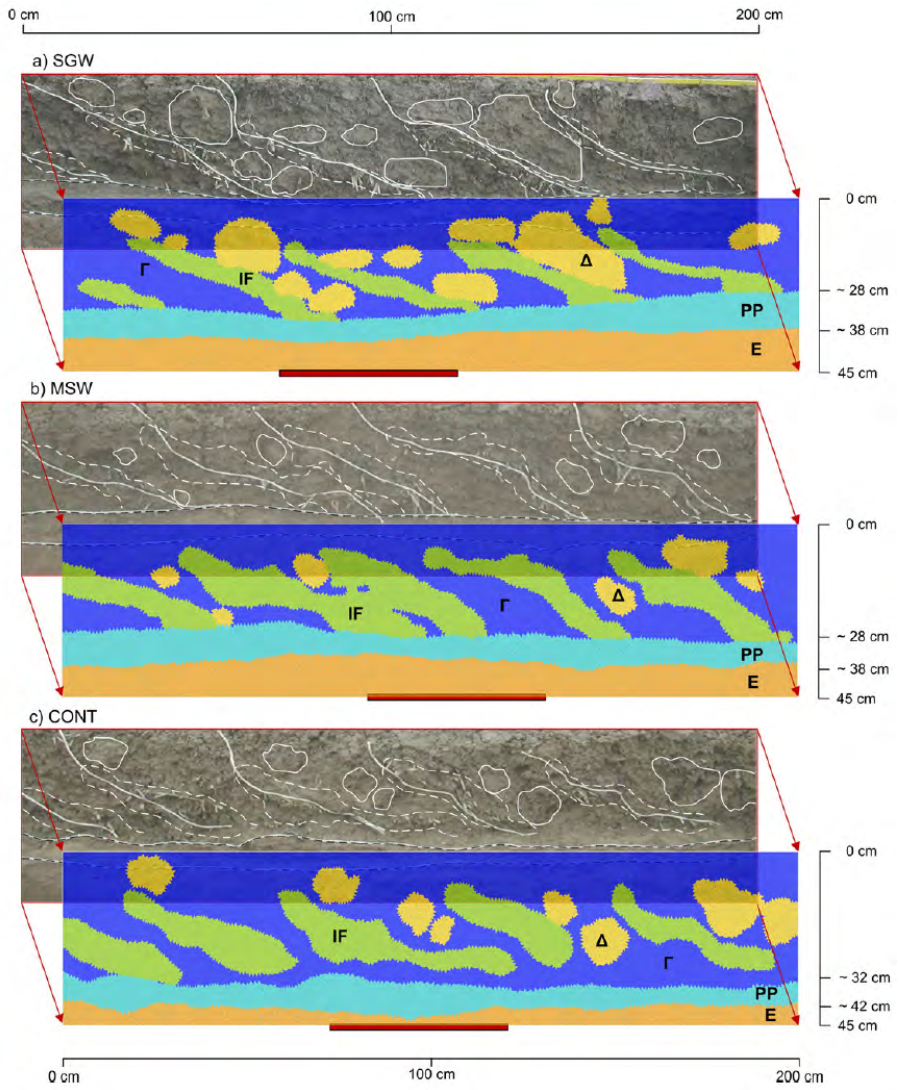
- *SGW: co-compost made of sewage sludge and green wastes*
- *MSW: compost made of municipal solid wastes*
- *CONT: control*

The Qualiagro field trial



- *IPU LOQ: 0.02 µg/L*
- *Near-saturated K (−0.6, −0.4, −0.2, −0.125 and −0.05 kPa) measured in each plot for each type of soil structure*
- *Water retention measured on 50 cm3 soil samples taken from each plot and soil structure*
- *Bulk density was determined from cylinders of 2.5 cm diam. and 4 cm length taken horizontally from each soil observation face at the nodes of a rectangular grid (0.36 m height, 1 m width) with 4-cm mesh*

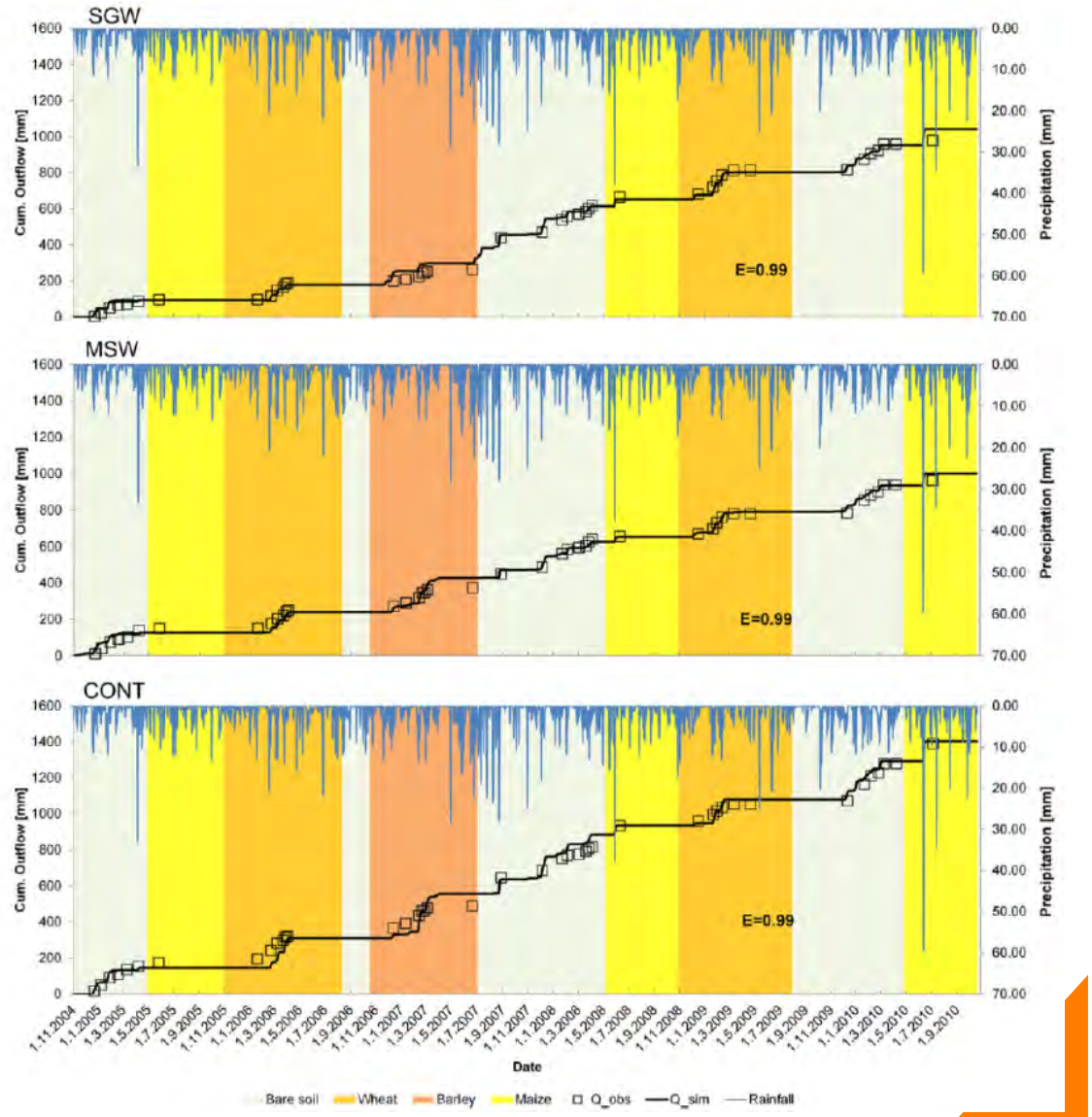
The Qualiagro field trial



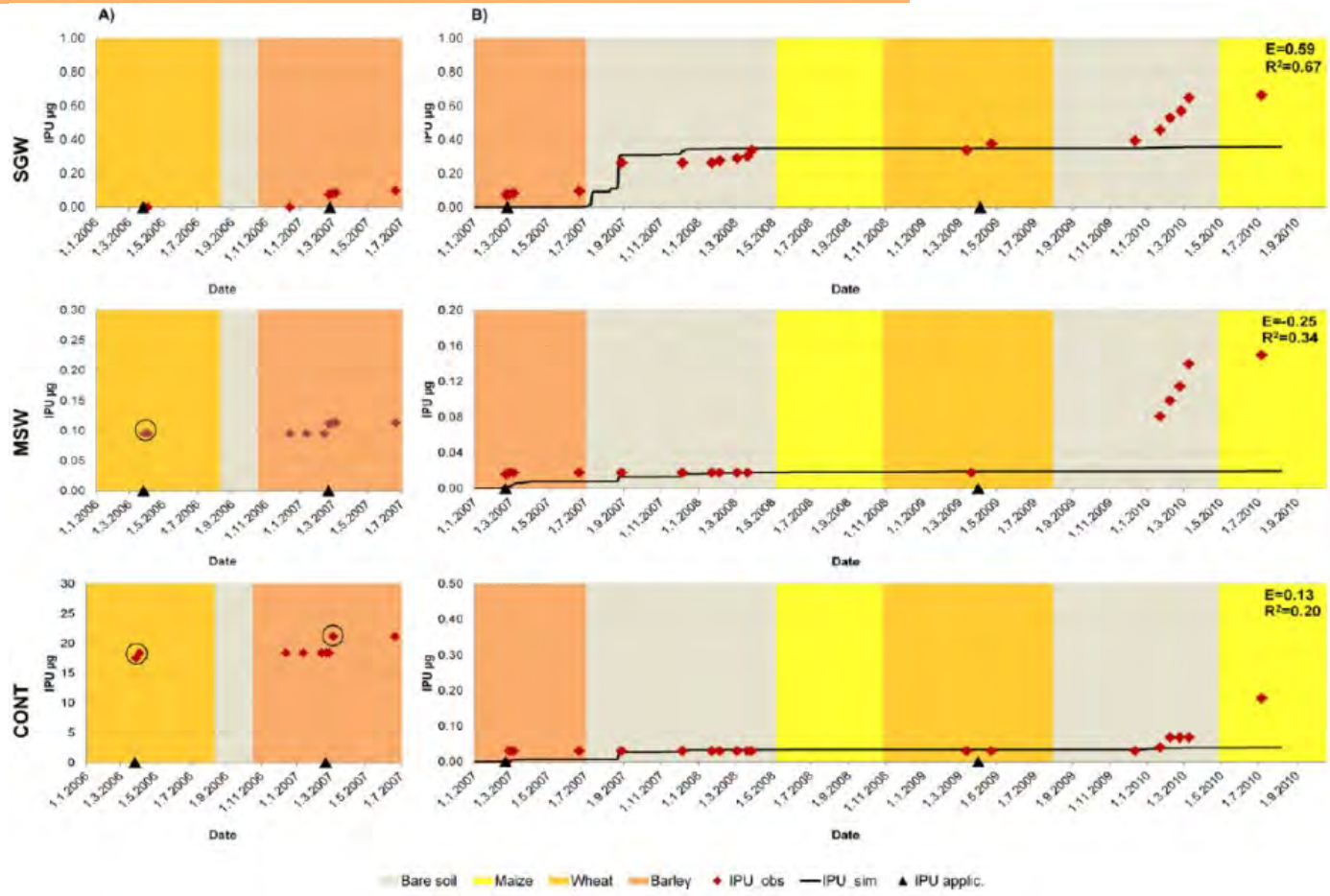
- *IPU Sorption and degradation rate measured in the lab for each plot for each type of soil structure*
- *Water flow and IPU transport modeled with HYDRUS-2D/3D (2 X 2 m domain)*
- *Seepage face (-70 cm)*
- *IC: equilibrium with -100 cm at the bottom*

Results

- *No outflow if independently measured parameters*
- *Water outflow from tension lysimeter very well predicted after calibration of Ks, alpha, n (on 2008 data)*



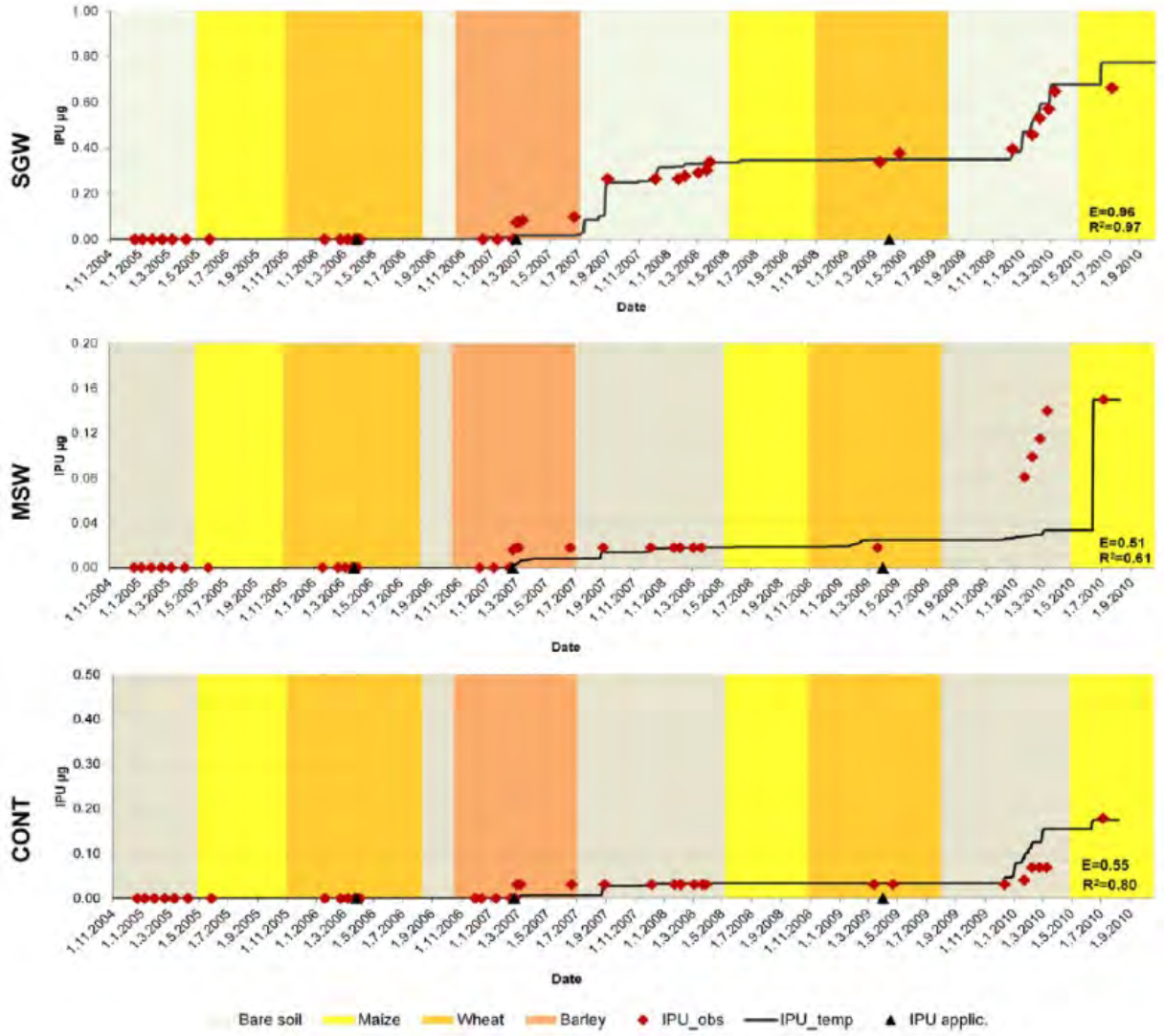
Results



- *Preferential transport!*
- *Degradation rates multiplied by 10, 2.4 and 4 for the SGW, MSW and CONT*
- *No effect of the last application*

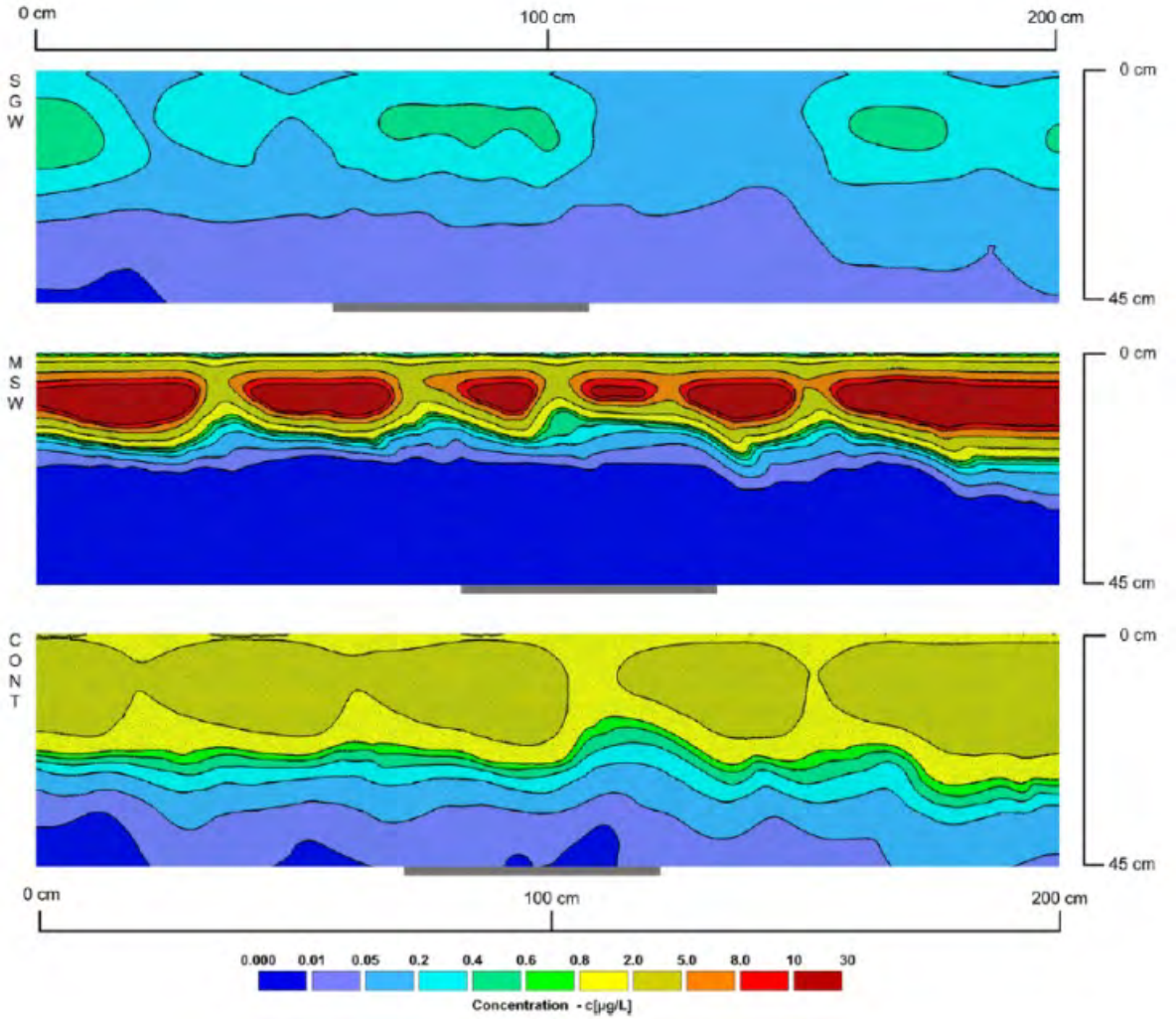
Results

- *Degradation rate lowered for the 2009/10 application (2 yr after the previous one)*



Results

- *IPU concentrations 186 days after the 2nd application*
- *Largest C in Γ soil*



Conclusions

- *There is a large variability of soil parameters than govern IPU fate and transport at the plot scale*
- *This variability can be (partly) explained by the heterogeneity created by tillage*
- *Independently-measured parameters are insufficient to properly describe IPU fate and transport*
- *Preferential (macropore) flow occurs in loamy soils!*

Parameters

Table 3
Soil hydraulic (after manual calibration) and solute transport parameters after for the SGW, MSW and CONT plots for each layer/structure (Γ structure, Δ structure, interfurrows - IF, plough pan - PP, E, BTI, BTII, BTICI, BTICII, and IC layers).

	Parameter	Layer/Structure									
		Γ	Δ	IF	PP	E	BTI	BTII	BTICI	BTICII	IC
		0-28 cm			28-38 cm	38-50 cm	50-70 cm	70-90 cm	90-120 cm	120-145 cm	145-200 cm
SGW	**Soil**										
	θ_r ($cm^3.cm^{-3}$)	0.0002	0	0	0.105	0	0.0006	0.0006	0	0	0
	θ_s ($cm^3.cm^{-3}$)	0.410	0.410	0.461	0.455	0.380	0.370	0.380	0.370	0.360	0.300
	α (cm^{-1})	0.0385	0.0073	0.024	0.042	0.015	0.024	0.028	0.020	0.029	0.032
	n	1.14	1.20	1.18	1.1	1.17	1.12	1.12	1.09	1.12	1.10
	K_s (cm day^{-1})	19.6	2.8	353	4.8	14	5.8	7.9	3.8	3.7	8.0
	Solute										
	K_d (L kg^{-1})	1.49	1.69	2.28	1.05	0.42	0.35	0.35	0.25	0.25	0.25
	μ (day^{-1})	0.0361	0.0513	0.0673	0.0361	0.0062	0.0065	0.0065	0	0	0
	D_L (cm)	4	4	4	11.9	11.9	11.9	11.9	11.9	11.9	11.9
	Basic										
	ρ_b (g cm^{-3})	1.40	1.57	1.26	1.63	1.50	1.50	1.50	1.38	1.38	1.38
	C_{org} (g kg^{-1})	12.2	12.2	18.05	10.5	3.46	2.03	2.03	1.19	1.19	1.66

	Parameter	Layer/Structure									
		Γ	Δ	IF	PP	E	BTI	BTII	BTICI	BTICII	IC
		0-28 cm			28-38 cm	38-50 cm	50-70 cm	70-90 cm	90-120 cm	120-140 cm	140-200 cm
MSW	**Soil**										
	θ_r ($cm^3.cm^{-3}$)	0.0002	0	0.0324	0.105	0	0.0006	0	0	0	0
	θ_s ($cm^3.cm^{-3}$)	0.410	0.426	0.467	0.455	0.380	0.370	0.370	0.370	0.300	0.300
	α (cm^{-1})	0.022	0.013	0.030	0.042	0.045	0.027	0.049	0.020	0.045	0.032
	n	1.20	1.20	1.18	1.10	1.17	1.12	1.09	1.09	1.10	1.10
	K_s (cm day^{-1})	10.6	7.2	489	6.0	14	9.0	7.0	3.8	8.0	4.0
	Solute										
	K_d (L kg^{-1})	1.26	1.42	1.37	0.90	0.42	0.35	0.35	0.25	0.25	0.25
	μ (day^{-1})	0.0282	0.0282	0.1560	0.0301	0.0062	0.0065	0.0065	0	0	0
	D_L (cm)	4	4	4	11.9	11.9	11.9	11.9	11.9	11.9	11.9
	Basic										
	ρ_b (g cm^{-3})	1.53	1.55	1.34	1.51	1.50	1.50	1.50	1.38	1.38	1.38
	C_{org} (g kg^{-1})	12.4	12.0	13.7	10.35	3.56	2.74	1.74	1.53	1.53	1.54

	Parameter	Layer/Structure									
		Γ	Δ	IF	PP	E	BTI	BTII	BTICI	BTICII	IC
		0-32 cm			32-43 cm	43-50 cm	50-70 cm	70-90 cm	90-120 cm	120-140 cm	140-200 cm
CONT	**Soil**										
	θ_r ($cm^3.cm^{-3}$)	0.0002	0	0	0.105	0	0.0006	0.0006	0	0	0
	θ_s ($cm^3.cm^{-3}$)	0.410	0.437	0.432	0.455	0.380	0.370	0.370	0.370	0.300	0.300
	α (cm^{-1})	0.0385	0.0134	0.0134	0.025	0.018	0.024	0.010	0.020	0.072	0.083
	n	1.14	1.21	1.18	1.10	1.17	1.12	1.12	1.09	1.09	1.10
	K_s (cm day^{-1})	14.0	13.3	1889	2.0	42	2.8	3.2	3.7	3.7	6.0
	Solute										
	K_d (L kg^{-1})	1.10	1.26	1.22	0.85	0.42	0.35	0.35	0.25	0.25	0.25
	μ (day^{-1})	0.0211	0.0211	0.0686	0.0239	0.0062	0.0065	0.0065	0	0	0
	D_L (cm)	4	4	4	11.9	11.9	11.9	11.9	11.9	11.9	11.9
	Basic										
	ρ_b (g cm^{-3})	1.35	1.63	1.27	1.70	1.50	1.50	1.50	1.38	1.38	1.38
	C_{org} (g kg^{-1})	9.4	9.7	10.55	7.55	4.15	2.36	2.36	1.72	1.59	1.60

θ_r – residual water content, θ_s – saturated water content, α and n – van Genuchten shape parameters, K_s – saturated hydraulic conductivity, K_d – sorption coefficient, μ – isoproturon degradation rate in liquid phase, D_L – longitudinal dispersivity, ρ_b – bulk density, C_{org} – organic carbon content.