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Joint Research Unit

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Integrating agricultural practices into the STICS model:
a new tool for simulating crop nitrogen fertilization

Introduction

Vulnerable zones with regard to nitrate pollution require adapted nitrogen fertilization practices. The objective was to develop a generic tool to allow the simulation of crop N fertilization in function of agricultural practices and pedoclimatic conditions at the crop rotation scale.

Material and methods

Simulations at the scale of the Merobert water catchment area (3670 ha, arable farming) situated near Chartres in France.

Crop N fertilization calculated using the COMIFER balance-sheet method.

One calculation at balance opening (mid February or April), updated at the first fertilisation date.

SticsRPacks/ SticsRFiles

R Studio

Pf = Crop N requirements (kg N ha^{-1})

fplt_1	nomsol	fplt_prec	Pf
wheat_plt.xml	Sol10930	wheat_plt.xml	264
wheat_plt.xml	Sol10930	pea_v10_plt.xml	297
sugarbeet_plt.xml	Sol10930		220
wheat_plt.xml	Sol16217	wheat_plt.xml	224
wheat_plt.xml	Sol16217	pea_v10_plt.xml	240
sugarbeet_plt.xml	Sol16217		220

Qminh = soil mineralisation (kg ha^{-1})

fplt_1	nomsol	Mh
wheat_plt.xml	Sol10930	44
sugarbeet_plt.xml	Sol10930	100
wheat_plt.xml	Sol16217	33
sugarbeet_plt.xml	Sol16217	82

Qminr = crop residues mineralisation (Mr + MrCI) (kg ha^{-1})

fplt_1	yield	MrCI1	MrCI2	MrCI3	MrCI4
mustard_CoverCrop_plt.xml	low	5	0	10	5
mustard_CoverCrop_plt.xml	medium	10	5	15	10
mustard_CoverCrop_plt.xml	high	15	10	20	15
fplt_1	ressuite	Mr1	Mr2		
wheat_plt.xml	straw+roots	-20	-10		
wheat_plt.xml	stubble+roots	0	0		
sugarbeet_plt.xml	straw+roots	20	10		

Nirr = N inputs due to irrigation (kg ha^{-1})

fplt_1	nomsol	Irr (mm)
wheat_plt.xml	Sol10930	0
sugarbeet_plt.xml	Sol10930	105

Xa = mineralisation of exogenous organic inputs (kg ha^{-1})

fplt_1	coderes	crespc	csurnres	qres	Keq1	Keq2	Keq3
sugarbeet_plt.xml	3	32	20	0	0.25	0.1	0.1
sugarbeet_plt.xml	3	22	20	0	0.6	0.2	0.1
sugarbeet_plt.xml	4	25	19	0	0.1	0.05	0.05
sugarbeet_plt.xml	5	25	10	0	0.35		
sugarbeet_plt.xml	6	40	8	0	0.65		

Rf = Soil mineral N content at harvest (kg ha^{-1})

nomsol	Rf
Sol10930	30
Sol15843	30
Sol16208	20

$$cropNfert = Pf - (Qminh + Qminr + Nirr + Xa - Rf + QNplantenp + (azomes + azamm40) - Qles)$$

Crop N fertilization — Initial N content in the crop — Initial Soil Mineral N content — Leached N

Results and discussions

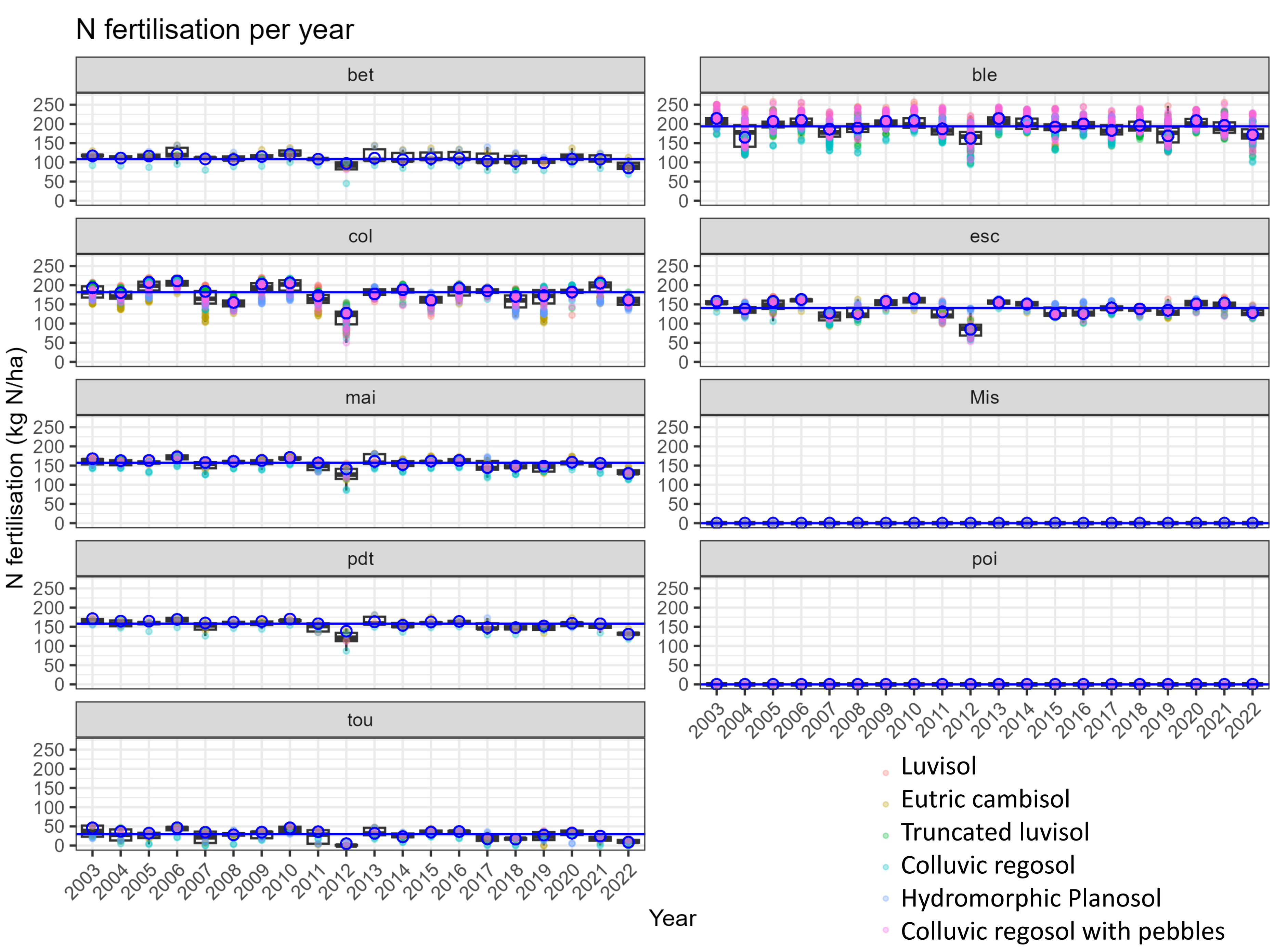

Figure 1: Annual N fertilization simulated by the model under conventional agriculture. The horizontal blue line corresponds to the weighted mean calculated over 20 years. **bet** = sugar beet; **ble** = winter wheat; **col** = rapeseed; **esc** = winter barley; **mai** = maize; **pdt** = potato; **poi** = spring pea; **tou** = sunflower; **Mis** = miscanthus.

Crop N fertilization (kg N ha^{-1})	Winter wheat	Rapeseed	Winter barley	Corn	Spring pea	Potato	Sugar beet
Simulation	194 ± 17	183 ± 20	141 ± 20	157 ± 10	0	158 ± 10	108 ± 8
Observation	190	170	145	140	0	140	90

Table 1: Average nitrogen fertilization simulated and observed for different crops at the scale of the WCA (data from the Eure-et-Loir Chamber of Agriculture).

Simulated N fertilization is consistent with observed farmers' practices (Table 1).

Year and soil type significantly affect N fertilization simulated by the model ($p < 0.01$) (Figure 1).

Crop rotation effect is weaker (only significant for wheat and rapeseed).

Conclusions

A robust tool was developed to simulate crop N fertilization at crop rotation scale while accounting for pedoclimatic and agricultural practices variability.

The tool supports the assessment of N management strategies in vulnerable water catchment areas.

Full integration in the SticsRpacks packages and STICS model and evaluation remain to be completed.

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