

Annexes

Soil type	FLIPP	FLC			HPGS		
Horizon	0 – 23 cm (Pots)	0 – 15 cm	15 – 37 cm	Pots (mean)	0 – 10 cm	10 – 40 cm	Pots (mean)
Texture	Sandy loam	Sandy loam	Clayey loam	-	Clayey loam	Clayey loam	Clayey loam
Clay (%)	10.0	16.6	34.9	20.2	30.4	39.9	34.4
Fine silt (%)	6.6	9.6	13.6	10.4	10.6	14.2	12.1
Coarse silt (%)	6.2	10.3	10.8	10.4	18.9	17.5	18.3
Total silt (%)	12.8	19.9	24.4	20.8	29.6	31.7	30.5
Fine sand (%)	8.5	13.5	11.5	13.1	13.0	9.0	11.3
Coarse sand (%)	68.9	50.1	29.3	45.9	27.1	19.4	23.8
Total sand (%)	77.4	63.5	40.7	59.0	40.1	28.4	35.1
Indice de battance	0.95	0.95	0.72	0.91	0.75	0.79	0.77

Annex 1: Soils physical properties. *These results are retrieved from soil analyses conducted by Drissa CISSE in 2018 on soils similar to those used in this study, in the region of Koumbia, Burkina Faso.*

Soil type	FLIPP	FLC			HPGS		
Horizon	0 – 23 cm (Pots)	0 – 15 cm	15 – 37 cm	Pots (mean)	0 – 10 cm	10 – 40 cm	Pots (mean)
Total N (%)	0.012	0.031	0.020	0.028	0.043	0.019	0.033
P (mg/100g)	0.090	0.098	0.042	0.087	0.086	0.062	0.076
K (mg/100g)	5.46	7.08	2.51	6.174	18.54	14.04	16.60
Ca (mg/100g)	22.45	37.09	35.23	36.72	64.83	53.43	59.94
Mg (mg/100g)	4.15	5.92	5.67	5.88	12.23	12.72	12.44
Mn (mg/100g)	50.68	36.14	27.76	34.48	122.94	89.52	108.60
Na (mg/100g)	0.00	0.00	0.00	0.00	0.00	0.51	0.22
Cl (mg/100g)	1.99	1.87	1.52	1.80	3.63	1.64	2.77
Fe (mg/100g)	17.68	18.05	16.91	17.82	27.25	18.75	23.60
Organic C (g/kg)	2.74	3.31	3.31	3.31	4.97	1.88	3.64
Humus (%)	0.55	0.66	0.48	0.63	0.99	0.38	0.73
C/N	23.82	10.86	11.89	11.06	11.44	9.68	10.69
pH-H ₂ O	6.67	6.61	5.24	6.34	6.73	6.84	6.78
pH-KCl	5.58	5.32	4.59	5.18	5.67	5.42	5.56
Δ (pH-H ₂ O - pH-KCl)	1.09	1.29	0.65	1.16	1.06	1.42	1.214
CEC (meq/100g)	1.65	11.05	4.12	9.68	5.21	5.020	5.128
Conductivity (μS/Cm)	19.5	13.5	5.6	11.9	42.8	22.8	34.22

Annex 2: Soils chemical properties. *These results are retrieved from soil analyses conducted by Drissa CISSE in 2018 on soils similar to those used in this study, in the region of Koumbia, Burkina Faso.*

								Description		Cotton		Rice		Maize	
								Sample number		119049331		119049332		119049333	
Parameter	Lab	Accr.	Method	GW 1 ar	GW 1 db	GW 2 ar	GW 2 db	LOQ	Unit	ar	db	ar	db	ar	db
Biochar properties															
Bulk density	FR	JE02	DIN 51705: 2001-06						kg/m³	70	-	134	-	79	-
specific surface (BET)	SUIB/o		DIN 66137/DIN ISO 9277						m²/g	-	1.7	-	8 *	-	4 *
true density	SUIB/o		DIN 66137/DIN ISO 9277						g/cm³	-	1.4	-	1.6	-	1.4
water holding capacity (WHC)	SB99/o		DIN EN ISO 14238, A						% (w/w)	336.7	-	52.0	-	323.6	-
Moisture	FR	JE02	DIN 51718: 2002-06					0.1	% (w/w)	4.8	-	2.7	-	3.6	-
Ash content (550°C)	FR	JE02	DIN 51719: 1997-07					0.1	% (w/w)	7.3	7.6	52.8	54.3	4.3	4.4
Ash content (815°C)	FR	JE02	DIN 51719: 1997-07					0.1	% (w/w)	5.4	5.7	52.6	54.1	3.3	3.5
Volatile Compounds	FR	JE02	DIN 51720: 2001-03					0.2	% (w/w)	27.2	28.6	11.7	12.0	14.4	14.9
gross calorific value (Ho,V)	FR	JE02	DIN 51900-1: 2004-02					200	kJ/kg	26700	28000	15500	16000	31100	32300
net calorific value (Hup)	FR	JE02	DIN 51900-1: 2004-02					200	kJ/kg	25900	27300	15100	15600	30400	31700
Hydrogen	FR	JE02	DIN 51732: 2014-07					0.1	% (w/w)	2.9	3.1	1.8	1.8	3.0	3.1
Carbon	FR	JE02	DIN 51732: 2014-07		> 50		> 50	0.2	% (w/w)	71.2	74.8	41.0	42.2	80.5	83.6
Total nitrogen	FR	JE02	DIN 51732: 2014-07					0.05	% (w/w)	1.42	1.49	0.75	0.77	0.59	0.61
Oxygen	FR	JE02	DIN 51733: 2016-04						% (w/w)	14.2	14.9	1.1	1.2	9.0	9.3
Total inorganic carbon (TIC)	FR	JE02	DIN 51726: 2004-06					0.1	% (w/w)	0.3	0.3	0.1	0.1	0.2	0.2
carbonate-CO2	FR	JE02	DIN 51726: 2004-06					0.4	% (w/w)	1.0	1.1	0.4	0.5	0.7	0.7
carbon (organic)	FR	JE02	berechnet						% (w/w)	70.9	74.5	40.9	42.1	80.3	83.4
H/C ratio (molar)	FR	JE02	berechnet		< 0.6		< 0.6			0.49	0.49	0.52	0.51	0.44	0.44
H/Corg ratio (molar)	FR	JE02	berechnet		< 0.7		< 0.7			0.49	0.49	0.52	0.52	0.44	0.44
O/C ratio (molar)	FR	JE02	berechnet		< 0.4		< 0.4			0.150	0.150	0.020	0.021	0.084	0.084
Sulphur (S), total	FR	JE02	DIN 51724-3: 2012-07					0.03	% (w/w)	0.06	0.06	< 0.03	< 0.03	< 0.03	< 0.03
pH in CaCl2	FR		DIN ISO 10390: 2005-12	10		10				8.2	-	7.4	-	7.8	-
Conductivity	FR		BGK III. C2: 2006-09					5	µS/cm	1220	-	164	-	1060	-
salt content	FR		BGK III. C2: 2006-09					0.005	g/kg	1.65	1.73	0.433	0.445	1.74	1.81
salt content	FR		BGK III. C2: 2006-09					0.005	g/l	0.115	0.121	0.058	0.060	0.138	0.143
thermogravimetry TGA 950°C by N-Atm.	FR		TGA 701 D4C							see attachment	-	see attachment	-	see attachment	-

Elements from the micro wave pressure digestion acc. to DIN 22022-1: 2014-07

Annex 3: Test report from Eurofins laboratory according to EBC standards.

Parameter	Lab	Accr.	Method	Limit values				Description		Cotton		Rice		Maize	
				Sample number				119049331		119049332		119049333			
				GW 1 ar	GW 1 db	GW 2 ar	GW 2 db	LOQ	Unit	ar	db	ar	db	ar	db
Arsenic (As)	FR	JE02	DIN EN ISO 17294-2: 2005-02		< 13		< 13	0.8	mg/kg	-	< 0.8	-	< 0.8	-	< 0.8
Lead (Pb)	FR	JE02	DIN EN ISO 17294-2: 2005-02		< 150		< 120	2	mg/kg	-	< 2	-	3	-	< 2
Cadmium (Cd)	FR	JE02	DIN EN ISO 17294-2: 2005-02		< 1.5		< 1	0.2	mg/kg	-	< 0.2	-	< 0.2	-	< 0.2
Copper (Cu)	FR	JE02	DIN EN ISO 17294-2: 2005-02		< 100		< 100	1	mg/kg	-	13	-	7	-	7
Nickel (Ni)	FR	JE02	DIN EN ISO 17294-2: 2005-02		< 50		< 30	1	mg/kg	-	2	-	4	-	< 1
Mercury (Hg)	FR	JE02	DIN 22022-4: 2001-02		< 1		< 1	0.07	mg/kg	-	< 0.07	-	< 0.07	-	< 0.07
Zinc (Zn)	FR	JE02	DIN EN ISO 17294-2: 2005-02		< 400		< 400	1	mg/kg	-	12	-	36	-	77
Chromium (Cr)	FR	JE02	DIN EN ISO 17294-2: 2005-02		< 90		< 80	1	mg/kg	-	3	-	15	-	< 1
Boron (B)	FR	JE02	DIN EN ISO 17294-2: 2005-02					1	mg/kg	-	23	-	9	-	2
Manganese (Mn)	FR	JE02	DIN EN ISO 17294-2: 2005-02					1	mg/kg	-	61	-	435	-	14

Elements fr. the borate digestion of ash 550 °C acc. to DIN 51729-11: 1998-11

Phosphorus as P2O5	FR	JE02	DIN EN ISO 11885 (E22): 2009-09					0.1	% (w/w)	-	3.2	-	0.9	-	4.0
Magnesium as MgO	FR	JE02	DIN EN ISO 11885 (E22): 2009-09					0.1	% (w/w)	-	5.2	-	0.5	-	2.2
Calcium as Calciumoxid	FR	JE02	DIN EN ISO 11885 (E22): 2009-09					0.1	% (w/w)	-	25.9	-	0.6	-	1.3
Potassium as K2O	FR	JE02	DIN EN ISO 11885 (E22): 2009-09					0.1	% (w/w)	-	14.1	-	1.5	-	37.9
Sodium as Na2O	FR	JE02	DIN EN ISO 11885 (E22): 2009-09					0.1	% (w/w)	-	0.4	-	< 0.1	-	1.5
Iron as Fe2O3	FR	JE02	DIN EN ISO 11885 (E22): 2009-09					0.1	% (w/w)	-	2.6	-	3.5	-	1.2
Silicon as SiO2	FR	JE02	DIN EN ISO 11885 (E22): 2009-09					0.1	% (w/w)	-	12.5	-	77.9	-	15.9
sulphur as SO3	FR	JE02	DIN EN ISO 11885 (E22): 2009-09					0.1	% (w/w)	-	4.9	-	0.3	-	8.7

Elements fr. the borate digestion of ash 550°C acc. to DIN 51729-11:1998-11 (OS)

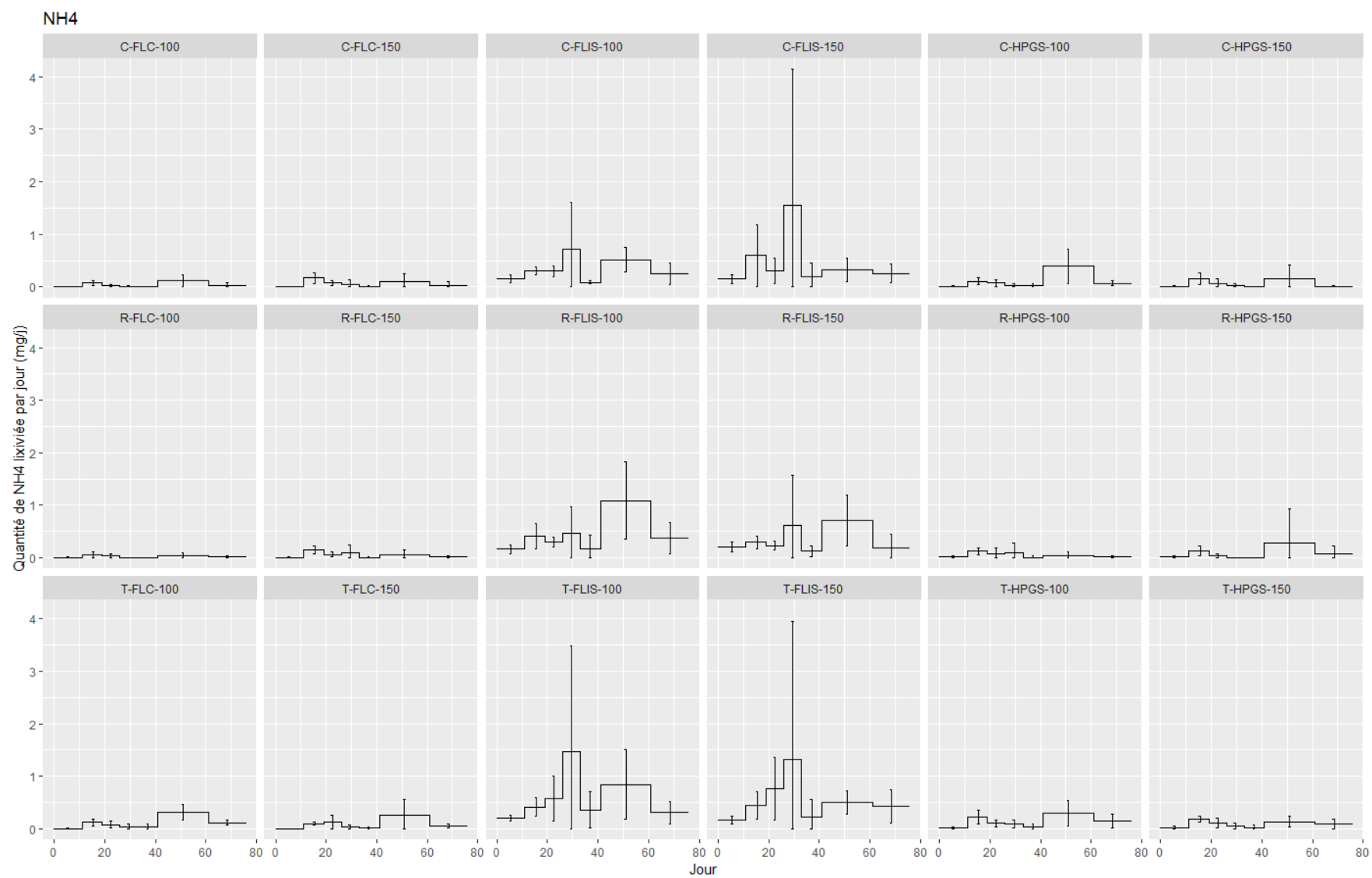
Parameter	Lab	Accr.	Method	Limit values				Description		Cotton		Rice		Maize	
				GW 1 ar	GW 1 db	GW 2 ar	GW 2 db	Sample number		119049331		119049332		119049333	
								LOQ	Unit	ar	db	ar	db	ar	db
Calcium (Ca)	FR	JE02	DIN EN ISO 11885 (E22): 2009-09						% (w/w)	-	1.4	-	0.2	-	0.0
Iron (Fe)	FR	JE02	DIN EN ISO 11885 (E22): 2009-09						% (w/w)	-	0.1	-	1.3	-	0.0
Potassium (K)	FR	JE02	DIN EN ISO 11885 (E22): 2009-09						% (w/w)	-	0.9	-	0.7	-	1.4
Magnesium (Mg)	FR	JE02	DIN EN ISO 11885 (E22): 2009-09						% (w/w)	-	0.2	-	0.2	-	0.1
Sodium (Na)	FR	JE02	DIN EN ISO 11885 (E22): 2009-09						% (w/w)	-	0.0	-	0.0	-	0.0
Phosphorus	FR	JE02	DIN EN ISO 11885 (E22): 2009-09						% (w/w)	-	0.1	-	0.2	-	0.1
Sulphur (S)	FR	JE02	DIN EN ISO 11885 (E22): 2009-09						% (w/w)	-	0.1	-	0.1	-	0.2
Silicon (Si)	FR	JE02	DIN EN ISO 11885 (E22): 2009-09						% (w/w)	-	0.4	-	19.8	-	0.3

Elements from toluene extraction

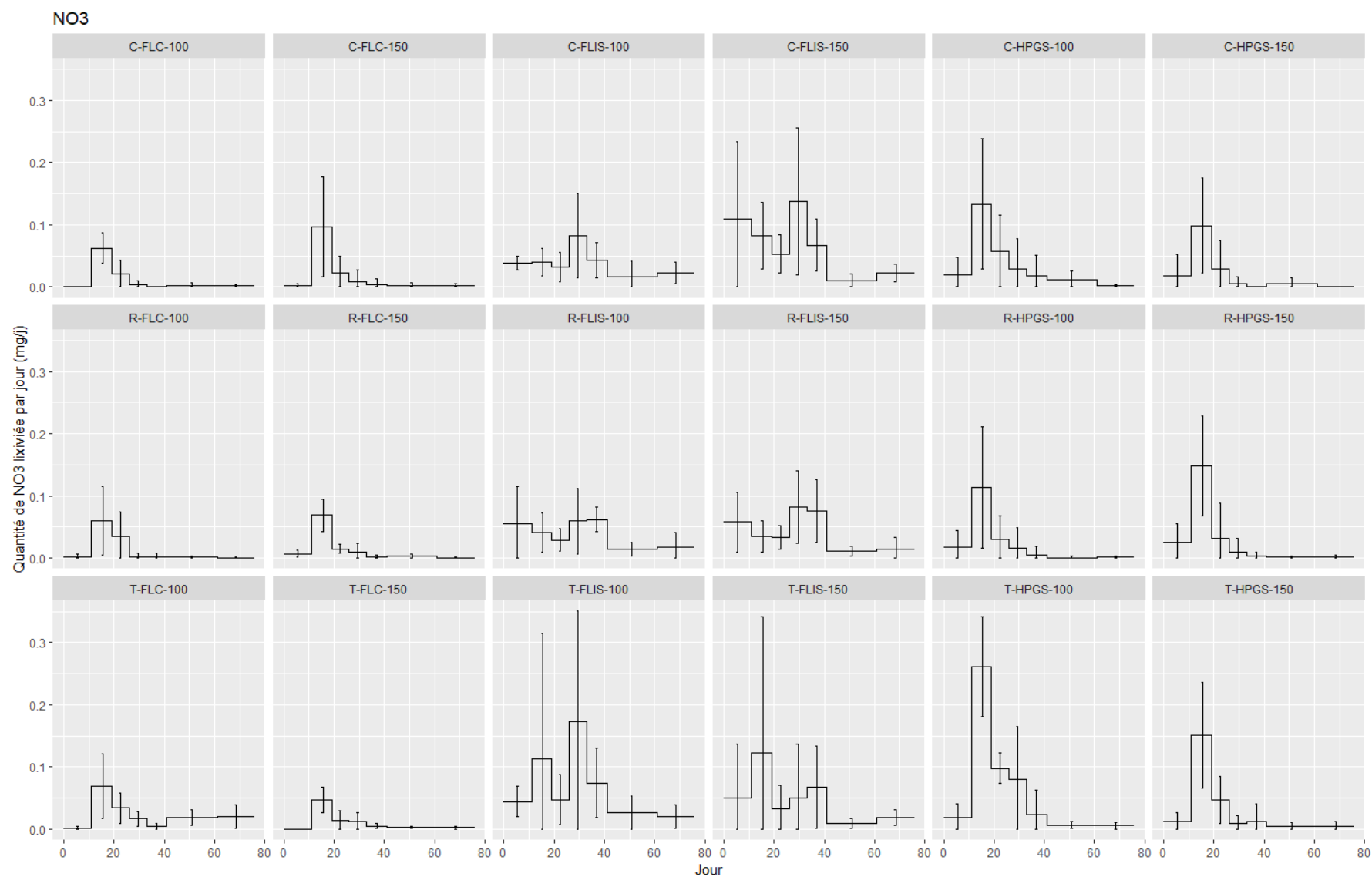
Parameter	Lab	Accr.	Method	Limit values				Description		Cotton		Rice		Maize	
				GW 1 ar	GW 1 db	GW 2 ar	GW 2 db	Sample number		119049331		119049332		119049333	
								LOQ	Unit	ar	db	ar	db	ar	db
Naphthalene	FR	JE02	DIN EN 16181:2017-11 (Norm-Entwurf)					0.1	mg/kg	-	3.8	-	10	-	5.1
Acenaphthylene	FR	JE02	DIN EN 16181:2017-11 (Norm-Entwurf)					0.1	mg/kg	-	< 0.1	-	< 0.1	-	< 0.1
Acenaphthene	FR	JE02	DIN EN 16181:2017-11 (Norm-Entwurf)					0.1	mg/kg	-	< 0.1	-	0.5	-	0.5
Fluorene	FR	JE02	DIN EN 16181:2017-11 (Norm-Entwurf)					0.1	mg/kg	-	0.3	-	1.1	-	1.2
Phenanthrene	FR	JE02	DIN EN 16181:2017-11 (Norm-Entwurf)					0.1	mg/kg	-	1.2	-	3.6	-	3.1
Anthracene	FR	JE02	DIN EN 16181:2017-11 (Norm-Entwurf)					0.1	mg/kg	-	0.2	-	0.9	-	0.9
Fluoranthene	FR	JE02	DIN EN 16181:2017-11 (Norm-Entwurf)					0.1	mg/kg	-	0.5	-	1.1	-	0.7
Pyrene	FR	JE02	DIN EN 16181:2017-11 (Norm-Entwurf)					0.1	mg/kg	-	0.8	-	1.2	-	0.6
Benz(a)anthracene	FR	JE02	DIN EN 16181:2017-11 (Norm-Entwurf)					0.1	mg/kg	-	0.3	-	0.5	-	0.3
Chrysene	FR	JE02	DIN EN 16181:2017-11 (Norm-Entwurf)					0.1	mg/kg	-	0.3	-	0.6	-	0.2
Benzo(b)fluoranthene	FR	JE02	DIN EN 16181:2017-11 (Norm-Entwurf)					0.1	mg/kg	-	< 0.1	-	0.2	-	< 0.1
Benzo(k)fluoranthene	FR	JE02	DIN EN 16181:2017-11 (Norm-Entwurf)					0.1	mg/kg	-	< 0.1	-	0.1	-	< 0.1
Benzo(a)pyrene	FR	JE02	DIN EN 16181:2017-11 (Norm-Entwurf)					0.1	mg/kg	-	0.2	-	0.2	-	0.1
Indeno(1,2,3-cd)pyrene	FR	JE02	DIN EN 16181:2017-11 (Norm-Entwurf)					0.1	mg/kg	-	< 0.1	-	< 0.1	-	< 0.1
Dibenz(a,h)anthracene	FR	JE02	DIN EN 16181:2017-11 (Norm-Entwurf)					0.1	mg/kg	-	< 0.1	-	0.1	-	< 0.1
Benzo(g,h,i)perylene	FR	JE02	DIN EN 16181:2017-11 (Norm-Entwurf)					0.1	mg/kg	-	< 0.1	-	< 0.1	-	< 0.1
Total 16 EPA-PAH excl. LOQ	FR	JE02	DIN EN 16181:2017-11 (Norm-Entwurf)		< 12		< 4		mg/kg	-	7.6	-	20.1	-	12.7

Soil type		FLIPP						FLC						HPGS					
Biochar type		Control		Cotton stalks		Rice husks		Control		Cotton stalks		Rice husks		Control		Cotton stalks		Rice husks	
NPK (kg ha ⁻¹)		100	150	100	150	100	150	100	150	100	150	100	150	100	150	100	150	100	150
N-NO ₃ ⁻ (mg)	mean	4.48*	3.12	2.70*	4.73*	2.61	2.71*	1.63	0.67*	0.83*	1.16*	0.61*	0.88	3.94	2.00	2.47*	1.09**	1.09*	1.78*
	std	3.68*	3.57	0.93*	2.94*	1.00	1.33*	0.53	0.13*	0.27*	0.88*	0.53*	0.16	0.95	0.85	1.51*	0.93**	1.04*	1.19*
	group	AB	ABC	ABCD	A	BCD	ABCD	CDE	DE	DE	CDE	E	DE	AB	CDE	BCDE	CDE	DE	CDE
N-NH ₄ ⁺ (mg)	mean	44.2	38.0	25.2*	36.0*	39.3	26.1*	10.1	8.0*	3.6	4.7*	1.9	4.0	11.7	7.2	10.8	2.0**	1.7*	8.6
	std	23.1	26.3	7.7*	33.3*	13.7	10.0*	3.46	6.9*	3.2	6.0*	1.8	3.1	7.5	4.4	7.9	1.2**	1.2*	15.3
	group	A	AB	BCD	AB	AB	BC	DE	E	E	E	E	E	CDE	E	CDE	E	E	E
P (mg)	mean	3.32	2.02	2.68	3.67*	3.08	2.70*	1.14	0.64*	0.47	0.55*	0.26	0.76	1.26	0.78	0.82	0.27**	0.25*	0.45
	std	1.55	0.88	1.25	3.02*	2.30	1.88*	0.09	0.40*	0.33	0.68*	0.17	0.88	0.81	0.45	0.72	0.14**	0.19*	0.46
	group	AB	BC	AB	A	AB	AB	CD	CD	D	D	D	CD	CD	CD	CD	D	D	D
K (mg)	mean	344	260	310	326*	280	272*	123	59*	46	54*	24	36	112	68	108	26**	20*	53*
	std	94	124	62	164*	81	110*	38	40*	40	98*	18	40	68	38	111	11**	15*	69*
	group	A	A	A	A	A	A	B	BC	BC	BC	C	BC	BC	BC	BC	BC	C	BC

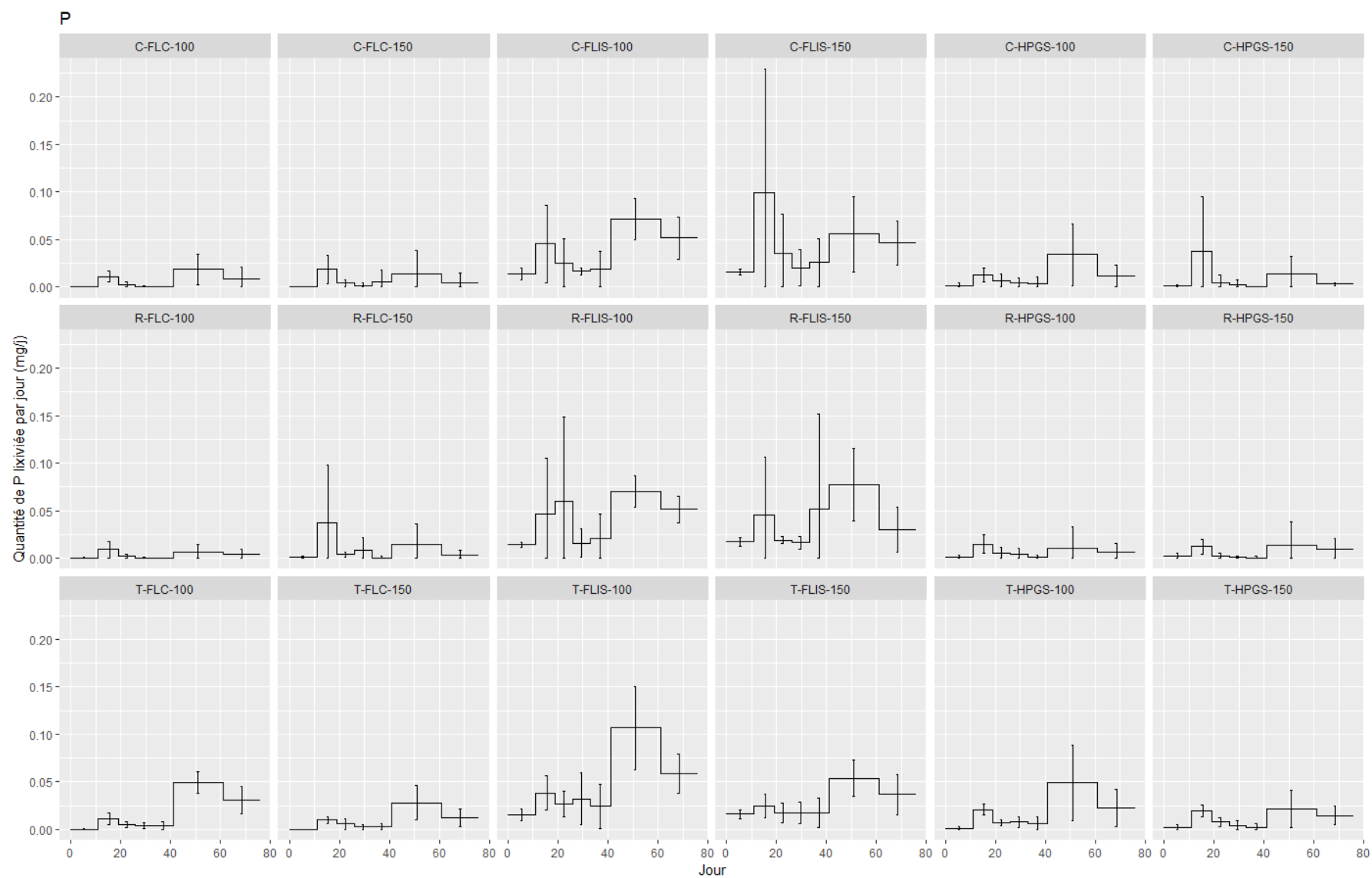
Annex 4: Total amounts of nutrients leached during the experiment. Means that do not share any letter are significantly different according to Fisher's LSD test [Yellow = control, Red / Green = significant decrease / increase compared to the corresponding control ($p < 0.05$)]. $n = 6$, *: $n = 5$, **: $n = 4$.



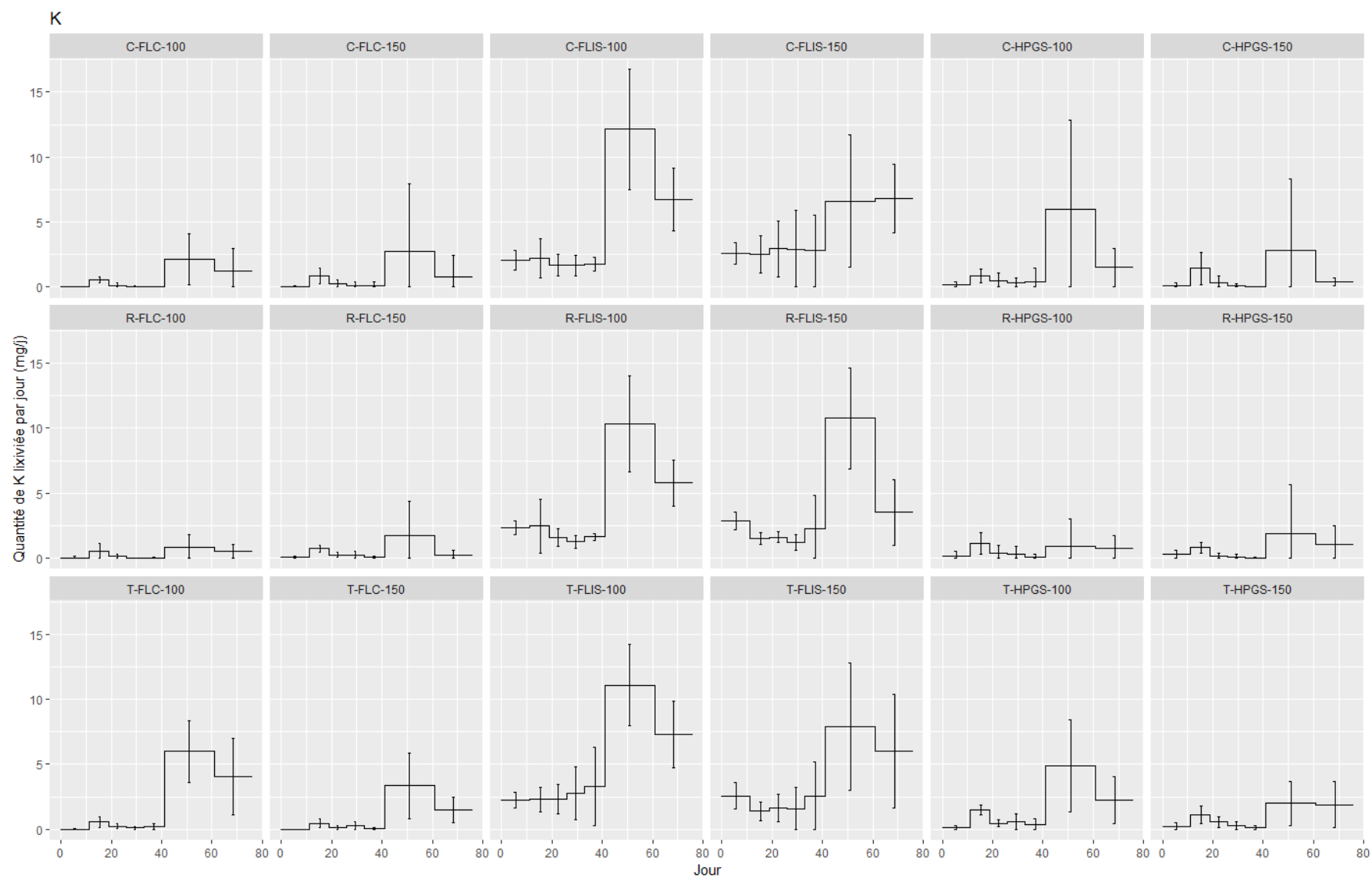
Annex 5: Evolution of NH₄⁺ leaching rate during the experiment for all modalities.



Annex 6: Evolution of NO₃⁻ leaching rate during the experiment for all modalities.



Annex 7: Evolution of P leaching rate during the experiment for all modalities.



Annex 8: Evolution of K leaching rate during the experiment for all modalities.