

Supplementary data

Quantifying CO₂ emissions and carbon sequestration from digestate-amended soil using natural ¹³C abundance as a tracer

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Appendix A.

Table S1. Additional soil physicochemical properties

		Loamy sand (S _{0.6})	Sand (S _{0.1})
Ca	g kg ⁻¹	2.2 ± 0.1	0.9 ± 0.2
Mg	g kg ⁻¹	0.0 ± 0.8	1.1 ± 1.1
Na	g kg ⁻¹	1.1 ± 1.1	2.9 ± 0.6
K	g kg ⁻¹	9.6 ± 0.9	9.3 ± 0.6
P	g kg ⁻¹	0.6 ± 0.0	0.1 ± 0.0
S	g kg ⁻¹	0.1 ± 0.0	0.0 ± 0.0
Al	mg kg ⁻¹	7337 ± 158	9399 ± 1046
Cd	mg kg ⁻¹	0 ± 0	0 ± 0
Cu	mg kg ⁻¹	0 ± 0	0 ± 0
Fe	mg kg ⁻¹	6250 ± 222	7756 ± 1085
Zn	mg kg ⁻¹	0 ± 0	0 ± 0
OM	g kg ⁻¹	19.6 ± 0.1	9.4 ± 0.1
Lignin	g kg ⁻¹	10.4	/
Cellulose	g kg ⁻¹	38.84	/

Ca = calcium; Mg = magnesium; Na = sodium; K = potassium; P = phosphorus; S = sulphur; Al = aluminium; Cd = cadmium; Cu = copper; Fe = iron; Zn = zinc; OM = organic matter.

Table S2. Additional physicochemical properties of the exogenous organic matter materials. Results are expressed on dry matter basis.

		MZ	MN	SF	DG1	DG2
P	(g kg ⁻¹)	1.6 ± 0.1	6.1 ± 0.3	8.5 ± 0.2	7.1 ± 0.2	7.3 ± 0.1
K	(g kg ⁻¹)	25.2 ± 0.8	28.1 ± 0.6	67.2 ± 1.6	58.0 ± 3.4	66.2 ± 1.1
Mg	(g kg ⁻¹)	1.9 ± 0.0	4.1 ± 0.2	6.0 ± 0.2	5.3 ± 0.1	3.5 ± 0.1
Ca	(g kg ⁻¹)	4.2 ± 0.1	9.2 ± 0.5	13.7 ± 0.4	11.8 ± 0.2	12.0 ± 0.1
S	(g kg ⁻¹)	1.6 ± 0.0	3.5 ± 0.0	4.8 ± 0.0	4.1 ± 0.0	4.9 ± 0.1
Na	(g kg ⁻¹)	1.4 ± 0.8	4.9 ± 0.3	2.1 ± 0.7	3.3 ± 0.9	1.2 ± 0.2
Al	(mg kg ⁻¹)	331 ± 17	1646 ± 175	285 ± 29	264 ± 24	292 ± 6
Cd	(mg kg ⁻¹)	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Cu	(mg kg ⁻¹)	7 ± 0	37 ± 2	22 ± 0	17 ± 1	19 ± 1
Fe	(mg kg ⁻¹)	271 ± 14	1410 ± 25	1227 ± 75	995 ± 137	2180 ± 161
Zn	(mg kg ⁻¹)	38 ± 4	144 ± 5	93 ± 5	71 ± 2	124 ± 3

Ca = calcium; Mg = magnesium; Na = sodium; K = potassium; P = phosphorus; S = sulphur; Al = aluminium; Cd = cadmium; Cu = copper; Fe = iron; Zn = zinc. MZ: maize; MN: manure; DG1 and DG2: digestate; SF: the solid fraction of digestate.

Table S3. Main parameters of the 2nd order kinetic model

	MZ	MN	SF	DG1	DG2
C_A	58.26720856	43.014201	15.535273	28.349099	48.943676
$k_2a(1 - a)$	0.001245794	0.0020867	0.0017778	0.0016602	0.0004737
R^2	0.998685	0.999129	0.988552	0.998359	0.966804
p	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001

C_A = the amount of mineralised C; k_2 = the second-order mineralisation rate; a = the amount of mineralised C-substrate that becomes part of the microbial biomass; R^2 = coefficient of determination. MZ: maize; MN: manure; DG1 and DG2: digestate; SF: the solid fraction of digestate.

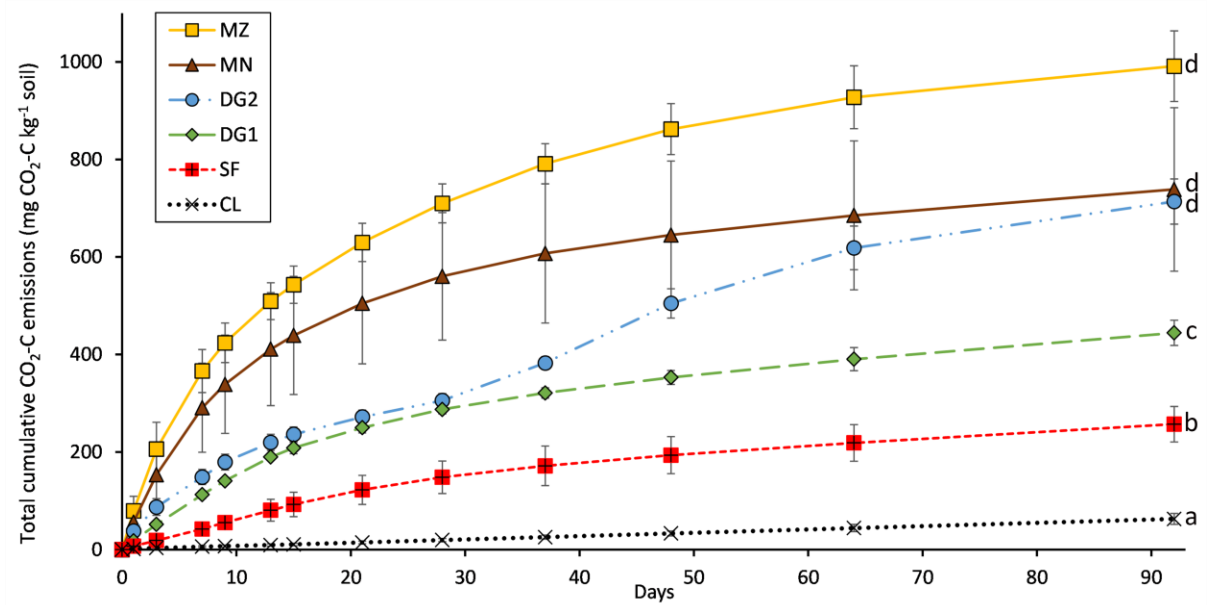


Fig. S1. Evolution of the total cumulative CO₂-C from the soil treatments over 92 days. MZ: maize; MN: manure; DG1 and DG2: digestate; SF: the solid fraction of digestate; CL: control soil with no addition of fertiliser.

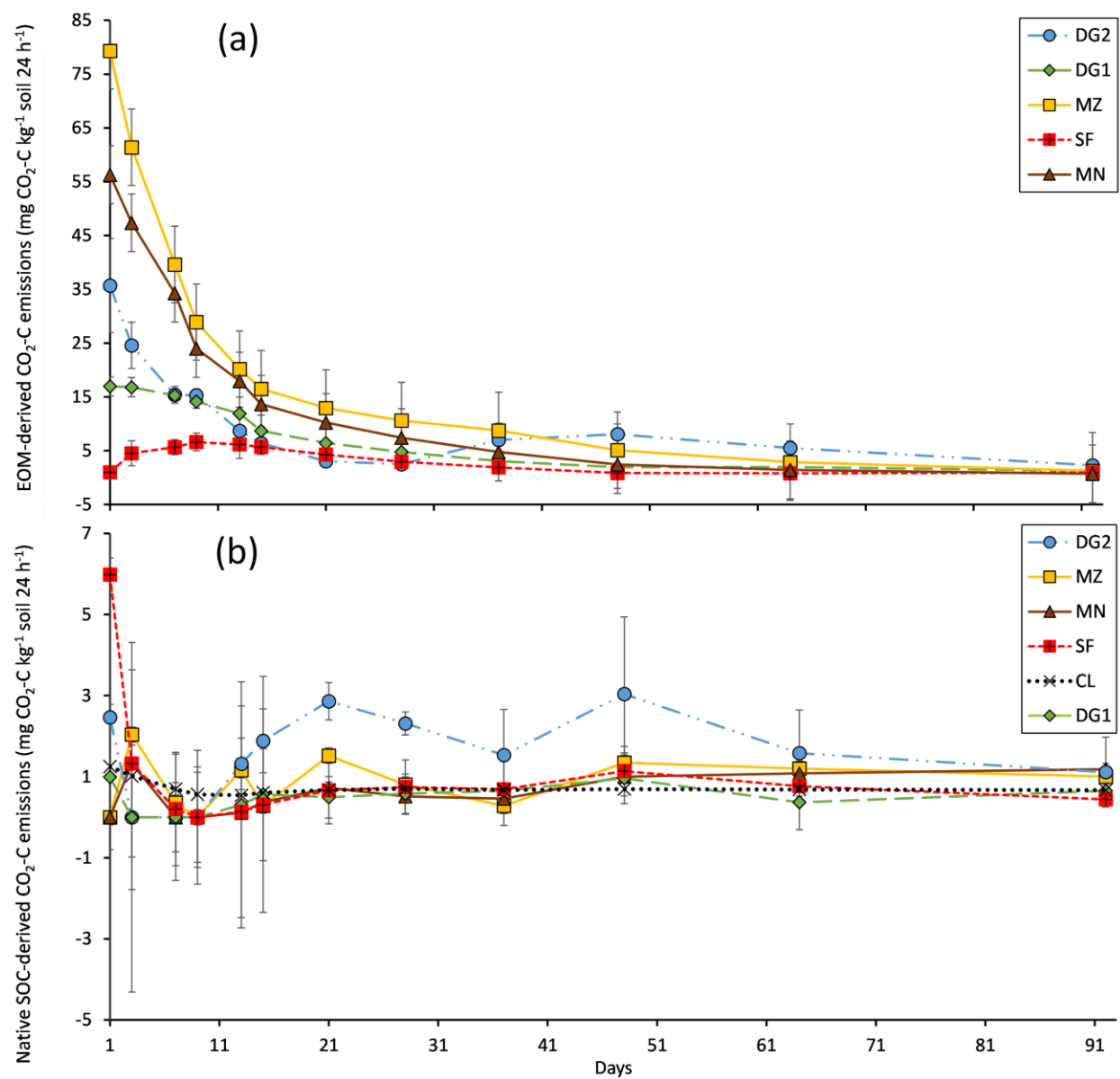


Fig. S2. Emissions from (a) the EOM-derived CO₂-C and (b) SOC-derived CO₂-C expressed as mg CO₂-C kg⁻¹ soil 24 h⁻¹ over 92 days. MZ: maize; MN: manure; DG1 and DG2: digestate; SF: the solid fraction of digestate; CL: control soil with no addition of fertiliser.

Table S4. Exogenous organic matter and soil-derived CO₂-C on last day (92) expressed as mg CO₂-C kg⁻¹ soil 24 h⁻¹

	EOM-derived (mg CO ₂ -C kg ⁻¹ soil 24 h ⁻¹)	Soil-derived
CL	/	0.67 ^a
MZ	1.27 ^a	1.01 ^a
MN	0.71 ^a	1.18 ^a
SF	0.94 ^a	0.44 ^a
DG1	1.27 ^a	0.65 ^a
DG2	2.29 ^a	1.11 ^a

MZ: maize; MN: manure; DG1 and DG2: digestate; SF: the solid fraction of digestate; CL: control soil with no addition of fertiliser. Treatments with the same letters are not statistically different according to Tukey's HSD test (significance level of 0.05).

Table S5. Amounts of N added with each treatment on first day of experiment

	N input on day 0 (mg kg ⁻¹ soil)				
	NH ₄ ⁺ -N	NO ₃ ⁻ -N	N _{min}	TN	N _{org}
MZ	4.64	3.92	8.56	90.61	82.05
MN	85.27	0.00	85.27	194.18	108.91
SF	10.43	0.00	10.43	142.17	131.74
DG1	86.67	0.00	86.67	242.39	155.72
DG2	190.03	0.00	190.03	396.58	206.55

TN = total nitrogen; NH₄⁺-N = ammonium nitrogen; NO₃⁻-N = nitrate nitrogen; N_{min} = the mineral N taken as the sum of NH₄⁺-N and NO₃⁻-N; N_{org} = organic nitrogen

Table S6. Amounts of residual N measured in the soil cores on last day of experiment

	Residual mineral N on day 92 (mg kg ⁻¹ soil)			
	NH ₄ ⁺ -N	NO ₃ ⁻ -N	N _{min}	N _{min} (subtracting CL)
CL	2.04	25.55	27.59	/
MZ	1.04	25.01	26.04	-1.54
MN	0.52	98.21	98.73	71.14
SF	0.46	36.89	37.35	9.76
DG1	0.40	136.09	136.49	108.91
DG2	0.39	174.20	174.58	147.00

NH₄⁺-N = ammonium nitrogen; NO₃⁻-N = nitrate nitrogen; N_{min} = the mineral N taken as the sum of NH₄⁺-N and NO₃⁻-N

Table S7. Main results of Pearson's correlations

	Priming	TOC _{min-EOM}	DOC/NH ₄ ⁺ -N	DOC/TOC	NH ₄ ⁺ -N _{added}	Lignin	Cellulose	pH _{D92}	MinN _{residual}	pH _{EOM}
Priming	1									
TOC _{min-EOM}	0.431	1								
DOC/NH ₄ ⁺ -N	0.003	0.673	1							
DOC/TOC	0.092	0.431	-0.004	1						
NH ₄ ⁺ -N _{added}	0.691	0.068	-0.578	0.494	1					
Lignin	0.064	-0.706	-.990**	-0.027	0.606	1				
Cellulose	0.637	0.713	-0.001	0.354	0.554	-0.052	1			
pH _{D92}	-0.530	-0.208	0.468	-0.752	-.941*	-0.469	-0.574	1		
MinN _{residual}	0.469	-0.054	-0.645	0.632	.956*	0.663	0.390	-.963**	1	
pH _{EOM}	-0.275	-0.874	-0.831	-0.504	0.084	0.824	-0.325	0.097	0.125	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).