Supplementary Material

Soil nematode trophic structure and biochar addition in recently converted boreal lands

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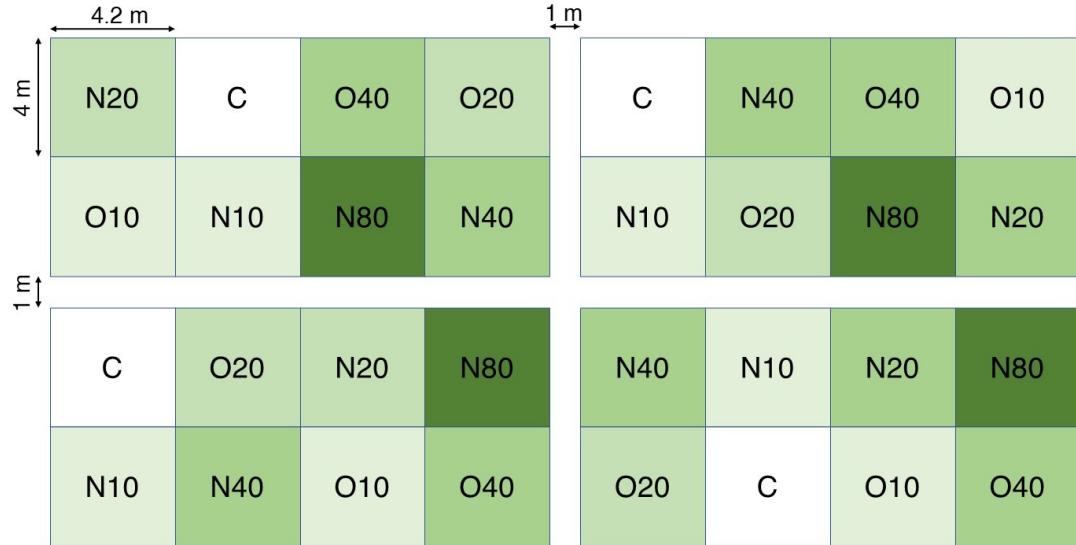
Supplementary data

Figure S1. Experimental design for the experiment. N=*double* application of biochar, once in 2013 and once in 2014. O=*single* application of biochar in 2013. 10, 20, 40, 80 refers to the rate of biochar applied to each plot in Mg C ha^{-1}. C=*control*, no biochar applied.

Table S1. Properties of unamended 0–15 cm depth soil and of biochar prior to application during spring of 2013 (after Abedin & Unc, 2021). CEC=effective cation exchange capacity, EC=electrical conductivity, SOM=soil organic matter, C=carbon, Ca=calcium, Mg=magnesium, K=potassium, P=phosphorus, S=sulphur, Fe=iron, Cu=copper, Mn=manganese, Zn=zinc, B=boron. Cations are Mehclich-3 available forms.

Soil (0–15 cm depth)		Biochar	
Parameter	values	Parameter	values
Texture	Loamy sand	Moisture (%)	4
Sand (%)	81.5	Organic C (kg kg^{-1})	0.69
Silt (%)	17.0	Inorganic C (kg kg^{-1})	0.009
Clay (%)	1.5	H:C$_{organic}$ ratio	0.68
pH	5.0	pH	8.1
CEC (cmol kg^{-1})	8.1	EC (mS cm^{-1})	0.69
SOM (%)	2.8		
Ca (ppm)	268	Ca (ppm)	27,100
Mg (ppm)	69	Mg (ppm)	2,100
K (ppm)	30	K (ppm)	9,100
P (ppm)	28	P (ppm)	700
S (ppm)	12	S (ppm)	600
Fe (ppm)	634	Fe (ppm)	1,900
Cu (ppm)	0.39	Cu (ppm)	10
Mn (ppm)	7.20	Mn (ppm)	1,290
Zn (ppm)	1.46	Zn (ppm)	125
B (ppm)	2		

Table S2. Mean and 95% confidence for soil properties, crop yields, and functional parameters of the biochar treatments. SOM=soil organic matter, SWC=soil water content, Ca=calcium, Mg=magnesium, K=potassium, P=phosphorus, Fe=iron, Cu=copper, Mn=manganese, Zn=zinc, B=boron, Na=sodium, Al=aluminium, S=sulphur, CEC=effective cation exchange capacity, BF=bacterivore abundance, FF=fungivore abundance, PF=herbivore abundance. Cations are Mehlich-3 available forms. Means can be found in Table 1 and Table 2 of the main text.

Soil property	Biochar application rate (Mg C ha^{-1})					Biochar treatment	
	0	10	20	40	80	Control	Biochar treated
pH	4.8 ± 0.5	5.4 ± 0.3	5.1 ± 0.2	5.6 ± 0.4	6.4 ± 0.3	4.8 ± 0.5	5.5 ± 0.2
SOM (%)	3.2 ± 1.0	3.0 ± 0.5	3.2 ± 0.4	3.6 ± 0.5	3.5 ± 1.1	3.2 ± 1.0	3.3 ± 0.2
CEC (cmol kg^{-1})	7.0 ± 1.6	7.8 ± 1.2	7.9 ± 1.2	8.2 ± 0.8	8.2 ± 3.0	7.0 ± 1.6	8.0 ± 0.5
SWC (%)	21.6 ± 6.3	20.1 ± 2.1	22.8 ± 2.3	23.9 ± 5.1	24.4 ± 6.6	21.6 ± 6.3	22.6 ± 1.6
Ca (ppm)	226.0 ± 123.7	425.4 ± 128.2	384.4 ± 83.5	658.4 ± 219.2	1013.0 ± 253.2	226.0 ± 123.7	564.2 ± 107.6
Mg (ppm)	25.5 ± 13.3	53.5 ± 20.7	40.9 ± 13.7	62.8 ± 26.0	91.3 ± 47.6	25.5 ± 13.3	57.9 ± 11.3
K (ppm)	115.5 ± 36.2	112.6 ± 19.6	126.1 ± 12.5	134.8 ± 15.6	141.3 ± 45.7	115.5 ± 36.2	126.9 ± 8.6
P (ppm)	137.8 ± 45.4	123.0 ± 20.6	158.9 ± 23.0	141.1 ± 22.3	120.8 ± 40.8	137.8 ± 45.3	138.1 ± 11.3
Fe (ppm)	589.5 ± 101.8	593.6 ± 51.9	584.3 ± 17.3	560.0 ± 27.5	512.5 ± 110.0	589.5 ± 101.8	569.8 ± 20.0
Cu (ppm)	3.2 ± 2.6	5.3 ± 2.6	5.5 ± 1.5	6.9 ± 2.8	5.1 ± 4.9	3.2 ± 2.6	5.8 ± 1.1
Mn (ppm)	15.2 ± 5.0	21.4 ± 5.9	22.8 ± 5.1	25.7 ± 6.1	30.7 ± 5.8	15.2 ± 5.0	24.4 ± 2.7
Zn (ppm)	4.1 ± 1.3	5.6 ± 1.9	6.4 ± 1.7	7.0 ± 2.4	5.4 ± 3.5	4.1 ± 1.3	6.2 ± 0.9
B (ppm)	1.7 ± 0.3	1.5 ± 0.3	1.6 ± 0.3	1.6 ± 0.2	1.6 ± 0.5	1.7 ± 0.3	1.6 ± 0.1
Na (ppm)	8.6 ± 1.1	7.5 ± 1.4	8.8 ± 1.7	7.9 ± 0.7	7.3 ± 2.6	8.6 ± 1.1	8.0 ± 0.6
Al (ppm)	1207.0 ± 92.4	1253.0 ± 71.9	1240.8 ± 31.0	1220.6 ± 64.6	1126.0 ± 157.1	1207.0 ± 92.4	1222.1 ± 31.6
S (ppm)	11.1 ± 1.6	12.3 ± 0.8	12.8 ± 1.1	14.5 ± 1.2	16.3 ± 3.1	11.1 ± 1.6	13.7 ± 0.7
Crop yield							
Root biomass (t ha^{-1})	0.0 ± 3.0	0.6 ± 2.1	1.8 ± 2.1	4.8 ± 2.1	9.4 ± 3.0	0.0 ± 0.0	3.4 ± 1.6
Leaf biomass (t ha^{-1})	0.1 ± 5.0	2.0 ± 3.5	3.6 ± 3.5	10.5 ± 3.5	17.4 ± 5.0	0.1 ± 0.15	7.1 ± 2.9
Functional parameter							
Total nematode count	380 ± 159	702 ± 217	699 ± 142	725 ± 171	667 ± 236	380 ± 159	703 ± 76
Bacterivore count	328 ± 95	612 ± 169	606 ± 114	649 ± 145	592 ± 249	328 ± 95	618 ± 63

Fungivore count	14 ± 26	24 ± 32	19 ± 16	14 ± 7	9 ± 10	14 ± 26	17 ± 9
Herbivore count	22 ± 26	21 ± 17	37 ± 50	17 ± 11	25 ± 27	22 ± 26	25 ± 13
Omnivore count	13 ± 16	35 ± 15	29 ± 20	37 ± 23	30 ± 24	13 ± 16	33 ± 8
Predator count	3 ± 8	10 ± 5	7 ± 7	8 ± 5	11 ± 10	3 ± 8	9 ± 3
FF/BF	0.039 ± 0.060	0.033 ± 0.030	0.035 ± 0.030	0.022 ± 0.010	0.016 ± 0.020	0.039 ± 0.060	0.028 ± 0.011
FF/(FF+BF)	0.037 ± 0.050	0.031 ± 0.030	0.033 ± 0.030	0.022 ± 0.010	0.015 ± 0.020	0.037 ± 0.054	0.026 ± 0.010
(FF+BF)/PF	46.0 ± 106.1	36.4 ± 21.2	46.1 ± 35.2	63.4 ± 43.1	50.4 ± 96.6	46.0 ± 106.1	49.4 ± 17.0
Simpson diversity	0.22 ± 0.20	0.22 ± 0.06	0.21 ± 0.11	0.19 ± 0.04	0.21 ± 0.17	0.22 ± 0.20	0.21 ± 0.03
Shannon-Weaver diversity	0.50 ± 0.40	0.50 ± 0.11	0.47 ± 0.20	0.43 ± 0.07	0.49 ± 0.34	0.50 ± 0.40	0.47 ± 0.06

Table S3. Pearson correlation coefficients between soil functional parameters, biochar rate treatment, and the soil physicochemcial properties. Only significant correlation coefficients greater than 0.50 are shown. Biochar application rates were 0, 10, 20, 40, and 80 Mg C ha^{-1}. Ca=calcium, Mg=magnesium, Mn=manganese, B=boron, S=sulphur. Cations are Mehlich-3 available forms.

Functional parameter	pH	Ca	Mg	Mn	B	S
				ppm		
Biochar rate	0.73***	0.80***	0.58***	0.55**		0.77***
Total nematode count			0.50**			
Bacterivore count		0.51**	0.53**			
Predator count						-0.50**
".". P<0.1, "*" P<0.05, "**" P<0.01, "***" P<0.001						

Table S4. Pearson correlation coefficients between the functional parameters. Only significant correlation coefficients greater than 0.50 are shown. FF=fungivore abundance, BF=bacterivore abundance, PF=herbivore abundance.

Functional parameter	Total	Bacterivore	Fungivore	Herbivore	Omnivore	FF/BF	FF/(FF+BF)	(FF+BF)/PF	Simpson diversity
			count 100 g dry soil^{-1}						
Bacterivore count	0.97***								
Herbivore count			0.52**						
Omnivore count	0.69***	0.59***							
FF/BF			0.89***	0.53**					
FF/FF+BF			0.88***	0.53**		1.00***			
Simpson diversity			0.59***	0.79***	0.55**	0.70***	0.70***	-0.60***	
Shannon-Weaver diversity			0.60***	0.76***	0.54**	0.71***	0.71***	-0.61***	1.00***

"." P<0.1, "*" P<0.05, "**" P<0.01, "***" P<0.001

Table S5. Pearson correlation coefficients between the soil properties. Only significant correlation coefficients greater than 0.50 are shown. Ca=calcium, Mg=magnesium, K=potassium, Fe=iron, Zn=zinc, Al=aluminium, Cu=copper, Mn=manganese, S=sulphur, CEC=effective cation exchange capacity, SOM=soil organic matter, SWC=soil water content. Cations are Mehlich-3 available forms.

Soil property	pH	Ca	Mg	K	Fe	Cu	Mn	S	CEC	SOM
					ppm				cmol kg^{-1}	%
Ca (ppm)	0.89***									
Mg (ppm)	0.85***	0.90***								
K (ppm)		0.56***								
Fe (ppm)	-0.59***									
Mn (ppm)		0.55**		0.54**		0.75***				
Zn (ppm)						0.94***	0.81***			
Al (ppm)	-0.54**	-0.56***	-0.59***		0.51**					
S (ppm)	0.68***	0.89***	0.73***	0.62***			0.56***			
CEC (cmol kg^{-1})								0.57***		
SOM (%)									0.54**	
SWC (%)										0.60***

"." $P<0.1$, "*" $P<0.05$, "**" $P<0.01$, "***" $P<0.001$

Table S6. Linear regression equations and model R^2 for the path relationships shown in Figure 3 of the main text. Fe=iron, Al=aluminium, Mn=manganese, Mg=magnesium, Ca=calcium, P=phosphorus, S=sulphur, B=boron. Soil cations are Mehlich-3 available forms.

Relationship (x-y)	Linear regression	R^2
pH-Fe	Fe=0-0.59pH	0.34
pH-Al	Al=0-0.54pH	0.29
pH-Mn	Mn=0+0.41pH	0.17
pH-Mg	Mg=0+0.85pH	0.73
Ca-pH	pH=0+0.89Ca	0.79
Fe-Al	Al=0+0.51Fe	0.26
pH-bacterivore count	bacterivore count=0+0.47pH	0.22
pH-omnivore count	omnivore count=0+0.44pH	0.20
pH-predator count	predator count=0+0.35pH	0.12
Ca-bacterivore count	bacterivore count=0+0.51Ca	0.26
P-bacterivore count	bacterivore count=0-0.03P	<0.00
S-bacterivore count	bacterivore count=0-0.48S	0.23
Mg-bacterivore count	bacterivore count=0+0.53Mg	0.28
B-predator count	predator count=0-0.50B	0.25
omnivore count-bacterivore count	bacterivore count=0+0.59omnivore count	0.35

Table S7. Mean nematode community trophic composition for all samples irrespective of biochar rate treatment (n=32). Error term is 95% confidence.

Trophic group	Mean count per 100 g dry soil
Bacterivore	582 ± 65
Fungivore	17 ± 8
Herbivore	25 ± 12
Omnivore	31 ± 8
Predator	8 ± 2
Total	662 ± 78

Table S8. Permutational multivariate analysis of variance (PERMANOVA) and Bray-Curtis dissimilarity matrix for nematode community trophic composition in soil amended with 0, 10, 20, 40, and 80 Mg C ha^{-1} biochar. Significant P values (α=0.10) indicate that nematode communities are dissimilar.

		Biochar application rate (Mg C ha^{-1})	0	10	20	40
Permutation N	9999					
Total sum of squares	0.90	10	0.008			
Within-group sum of squares	0.59	20	0.002	0.86		
F statistic	3.55	40	0.004	0.81	0.74	
P value (same)	0.008	80	0.058	0.99	0.96	0.88