Supplementary information

Table S1. Chemical and mineral composition of the basalt amendment.

Oxide	Percentage of total mass
SiO2	42
CaO	16
Al2O3	12
Fe2O3	11
MgO	11
K2O	3
Na2O	3
TiO2	2
P2O5	1
Mn2O3	0.2
ZrO2	0.1
BaO	0.1
SrO	0.1
SO3	0.04
Cr2O3	0.02
Moisture 105 °C	1.59

Element	Concentration (ppm)
Ba	1320
Sr	1037
Cr	408
V	396
Zr	240
Ce	156
Ni	147
Cu	121
Nb	119
Cu	110
Rb	101
Ni	95
Cr	93
La	91
Zn	68
Nd	64
Zn	59
Sc	29
Y	24
Th	12
Pb	7
Pb	5
U	3
As	2
Cl-	
Cd	<0.1
Loss on ignition	0.2

Mineral	Percentage of total mass
Plagioclase	38
Pyroxene	26
K-feldspar	10
2:1 Al clay	9
Olivine	7
Kaolinite	5
Ulvospinel	3
Quartz	1
Mica/illite	1

Table S2. Maximal mass changes during the CO_2 adsorption and desorption steps

Sample	Δm_{ads}, wt%	Δm_{des}, wt%
Soil without basalt	0.009	0.008
Soil with basalt	0.015	0.014
Basalt	0.019	0.023

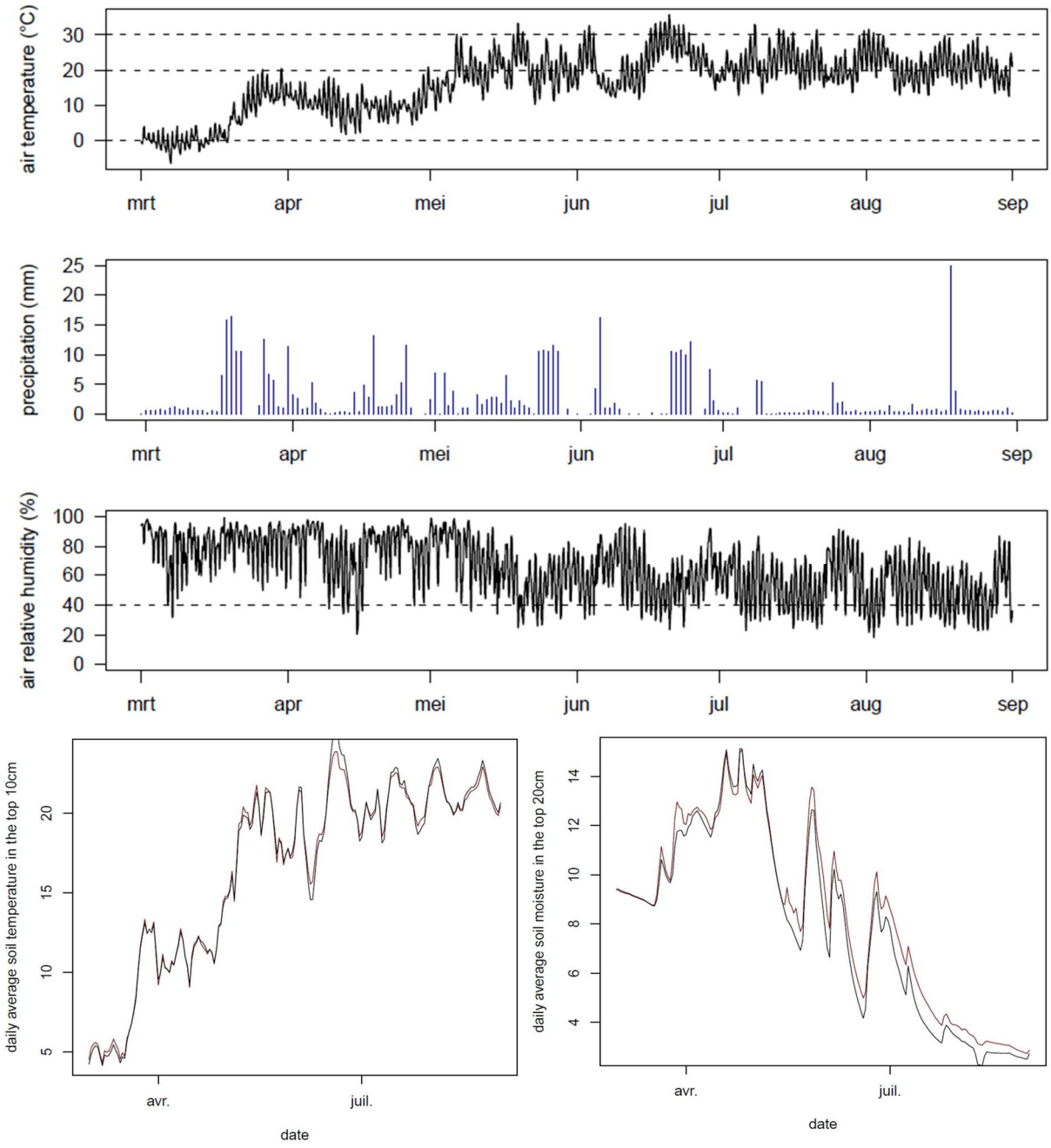

Figure S1. Climate conditions simulated in the ecotron. They correspond to local climate projections or the RCP 8.5 model for the year 2072 in a 15km pixel around Maastricht (Netherlands). For more details see (Rineau et al. 2019a; Vanderkelen et al. 2019). The two bottom panels show average topsoil temperature (left) and volumetric water content (right), as average values for control (black) and basalt-amended (red) units.

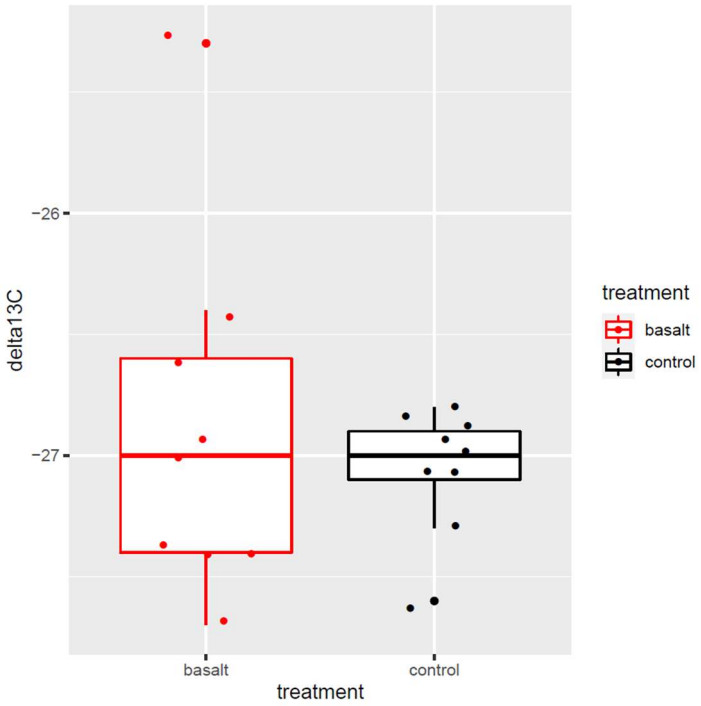

Figure S2. Effect of basalt treatment on the $\delta^{13}C$ signature of soil organic carbon (SOC). The CO_2 injected in every unit has a low isotopic C signature. The effect of basalt treatment has been tested by a mixed model with treatment as a fixed effect and unit as a random effect (F=0.36, df=4, p=0.58).

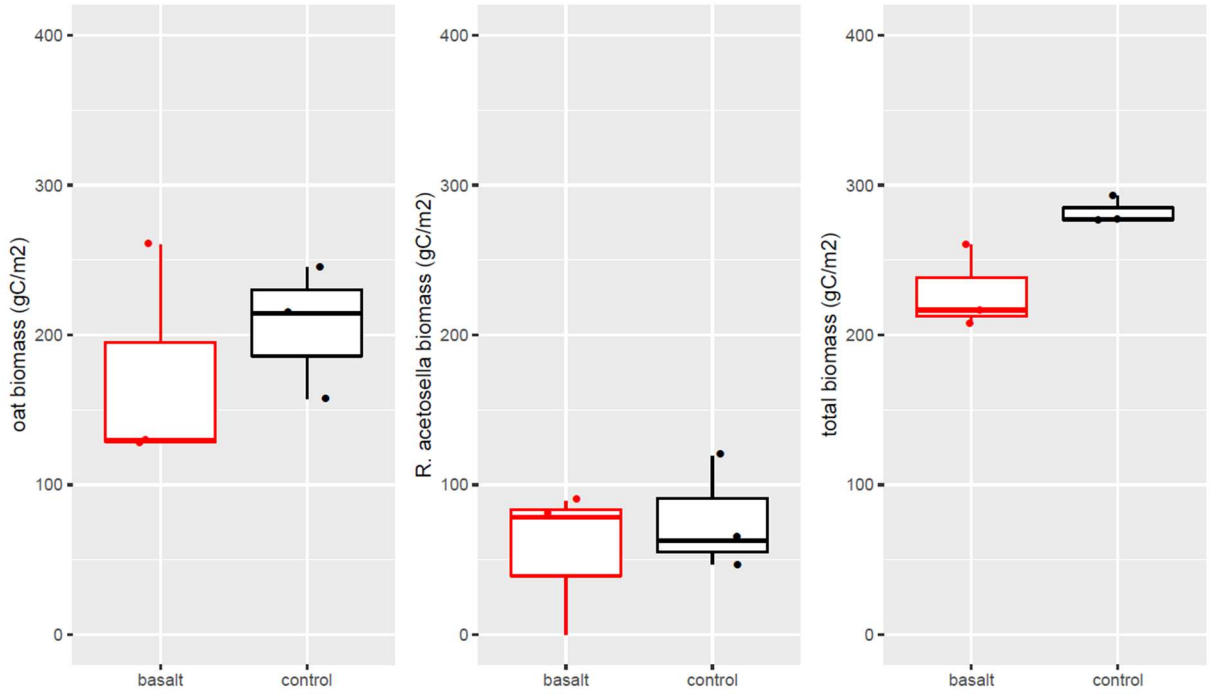

Figure S3. Effect of basalt treatment on oat (left), weed biomass (center) and total biomass (right) (gC/m2). Weed biomass was mostly consisting of Rumex acetosella *and was harvested manually at the end of June. The biomass of oats was calculated by multiplying the average plant density by the average of the sum of the dry weight of individual plant per unit, multiplied by the average C content of oat plants (40%). The biomass of R. acetosella (harvested at the end of the growing season and weighed fresh as a total value per unit) was calculated by correcting for the lysimeter surface (3.14m^2), for the average water content of these plants (10%), and for the average C content of R. acetosella plants (40%). The effect of basalt treatment on oat, R. acetosella and total plant biomass has been tested by a mixed model with treatment as a fixed effect and unit as a random effect, and was significant only for total biomass (F=10.04, df=1, p=0.03). Values for oat biomass: F=0.42, df=1, p=0.55. Values for R. acetosella biomass: F=0.34, df=1, p=0.59.*

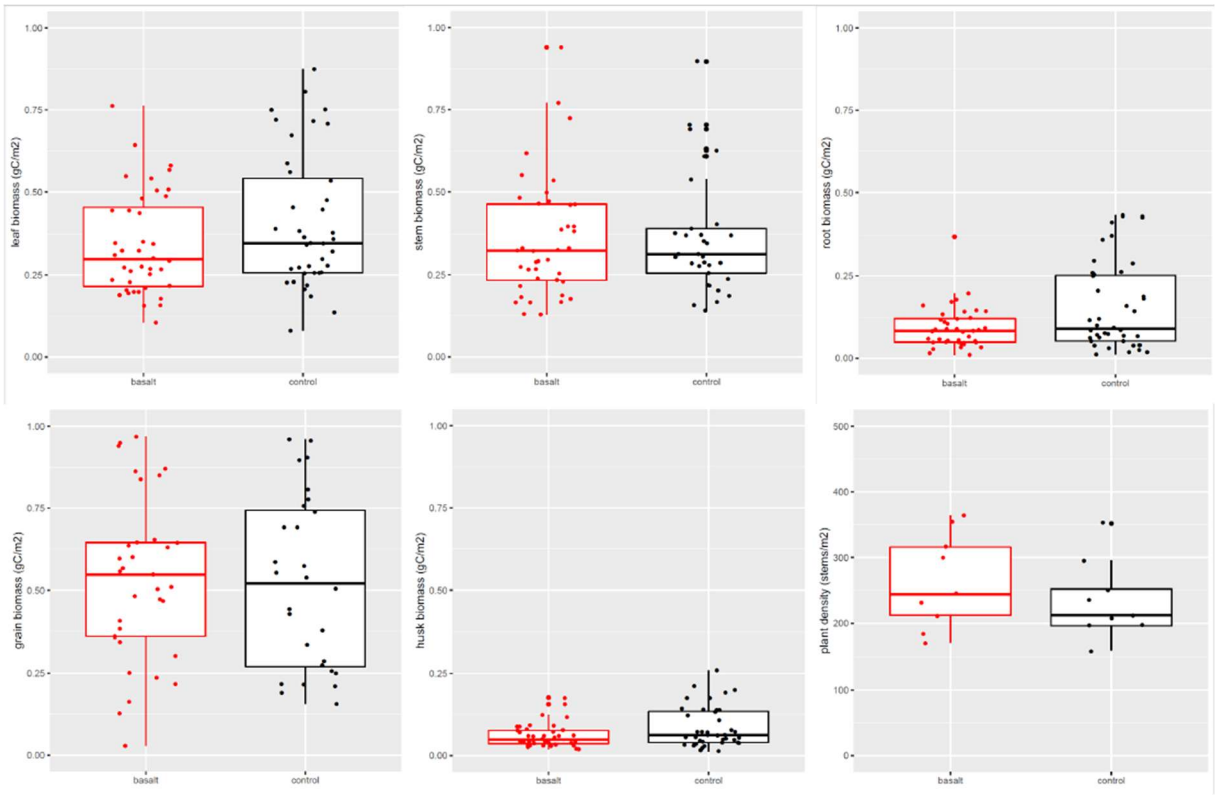

Figure S4. Effect of basalt amendment on the biomass of the organs of individual plants (n=20). Red: basalt treatment, black: control. The effect of treatment on every organ has been tested using a mixed model with treatment as a fixed variable (2 levels: basalt or control) and unit as a random variable, and was never significant.

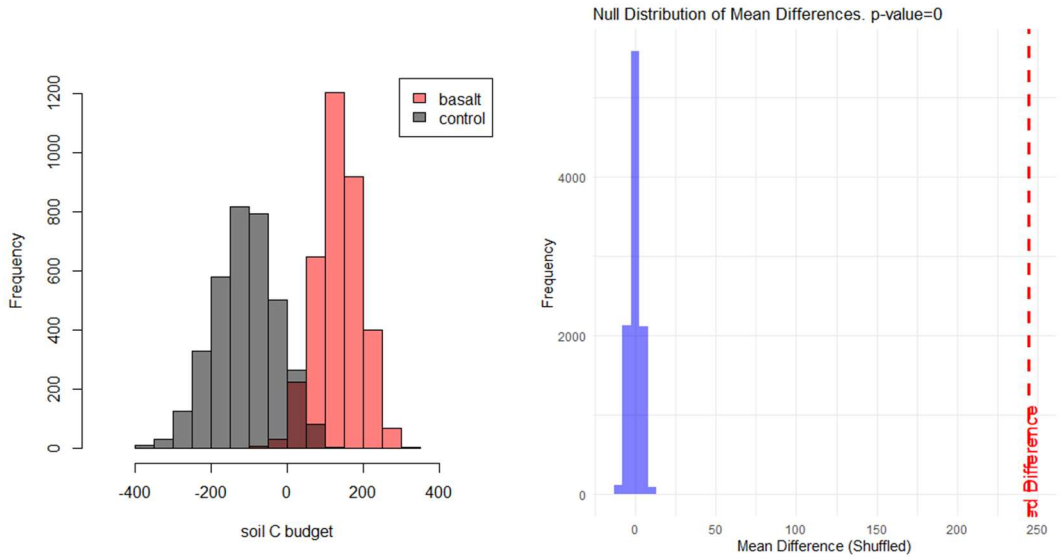

Figure S5. Effect of the basalt treatment on soil net C flux. The soil net C flux was calculated as the sum of the CO2 net flux, the CH4 net flux, the rainfall C flux, minus the leachate C flux, the sampling C flux, and the plant C flux (n=3 for each treatment). To account for the error propagation in the calculation process while comparing the soil net C flux between treatments, we used bootstrapping (n = 10 000) to generate a distribution of soil C net flux for each treatment (left panel; positive values indicate increase in soil C). We then compared these distributions using a bootstrap hypothesis test, assessing the observed difference between treatments (right panel) (red dashed line) against a null distribution representing no treatment effect (blue bars) (p=0).

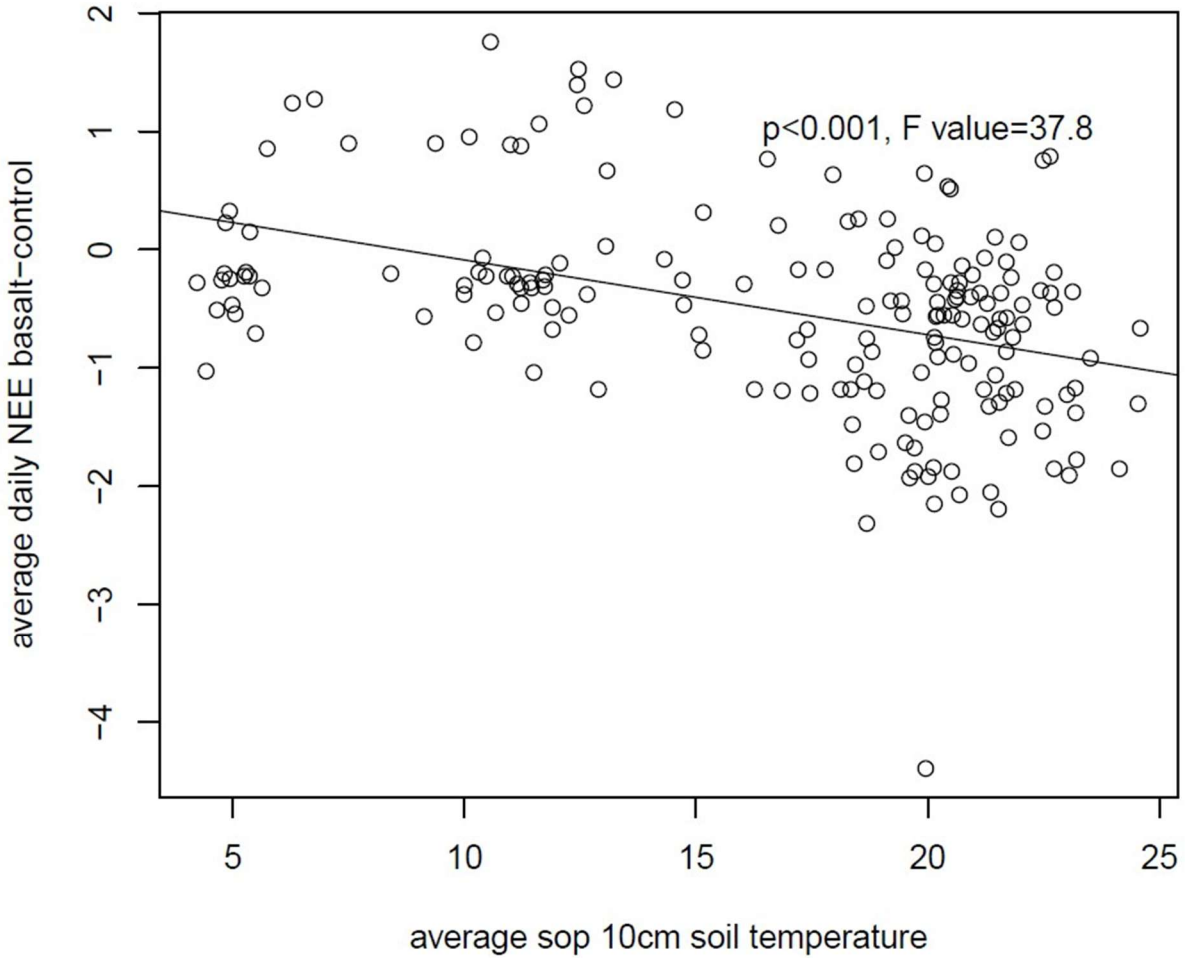

Figure S6. Correlation between cumulated NEE difference between treatments and average topsoil temperature. Every point represents the computed daily average in soil temperature recorded at 10cm depth by three different sensors per unit, for three units per treatment level in function of the daily average difference in CO2-C net flux. Effect of soil temperature and soil moisture on difference in C balance between the treatments was tested using a linear model with daily average ifference in CO2-C flux between treatments response variable and average soil temperature on the top 10cm and average soil moisture on the top 20cm as fixed variables; p-value = 0.06 for soil moisture; p-value = 3.8 e^{-9} for soil temperature).

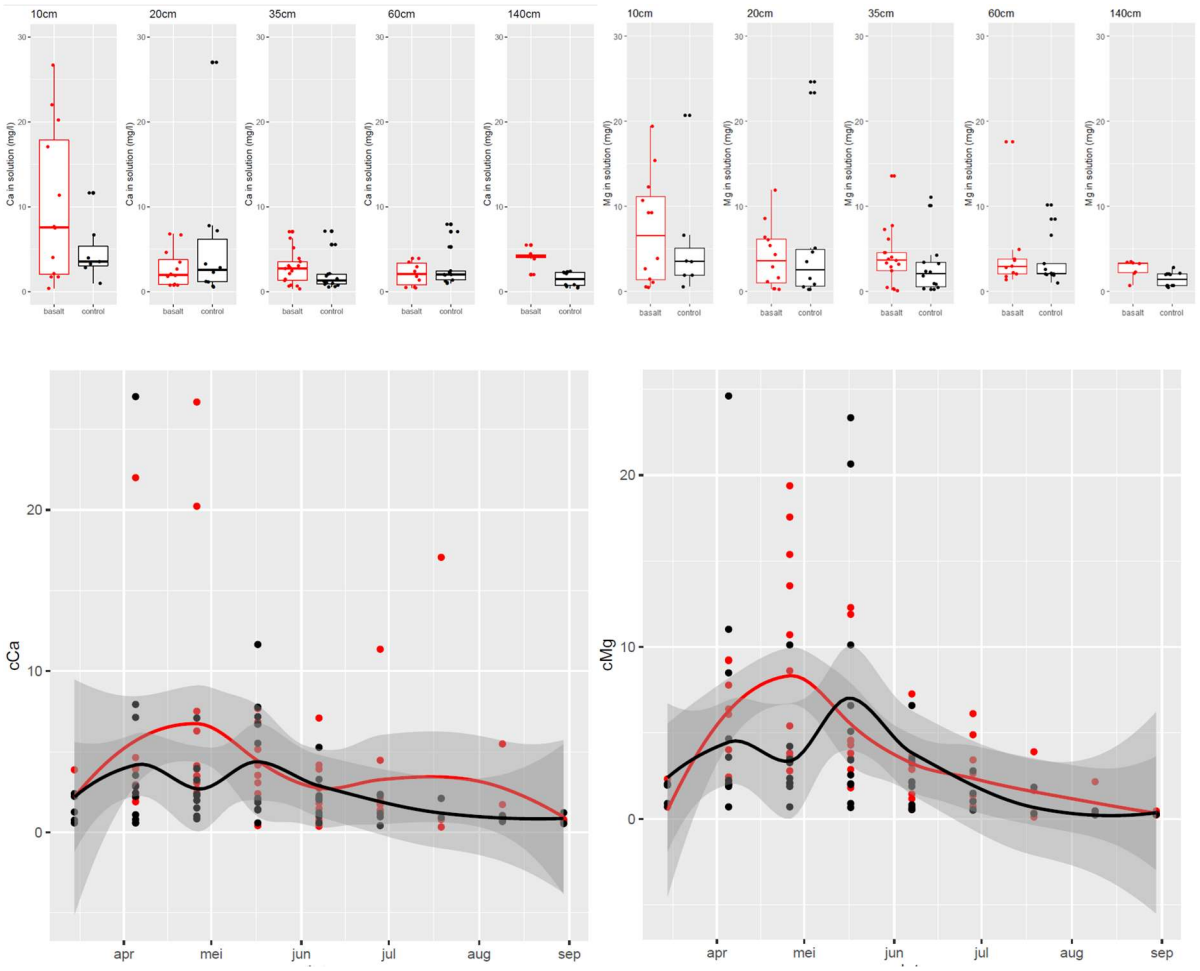

Figure S7. Effect of the basalt amendment on Ca and Mg in soil pore water at different depths (top) and its dynamics (bottom; red=basalt treatment, black=control; each point is a sample at a given date, unit and depth; the shaded zones represent the confidence interval). The effect of treatment on Ca and Mg concentration in the solution has been assessed at each depth using a mixed model with treatment as a fixed variable (2 levels: basalt or control) and unit and date as a random variables. The effect was not significant for any depth.

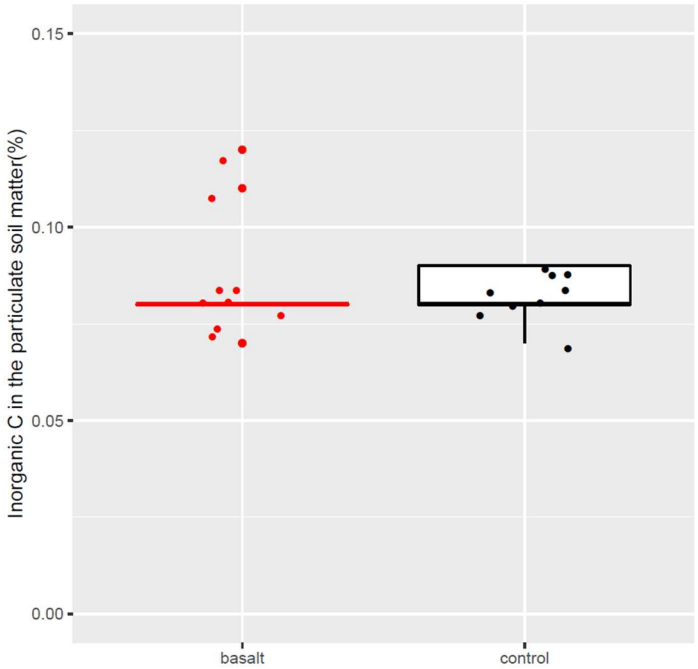

Figure S8. Effect of the basalt amendment on soil particulate inorganic Carbon (control: black, basalt treatment: red). This represents the fraction of carbonates and bicarbonate ions that did not dissolve in the soil solution. The effect of treatment has been assessed using a mixed model with treatment as a fixed variable (2 levels: basalt or control) and unit as a random variable. The effect was not significant (F=0.29, df=1, p=0.62).

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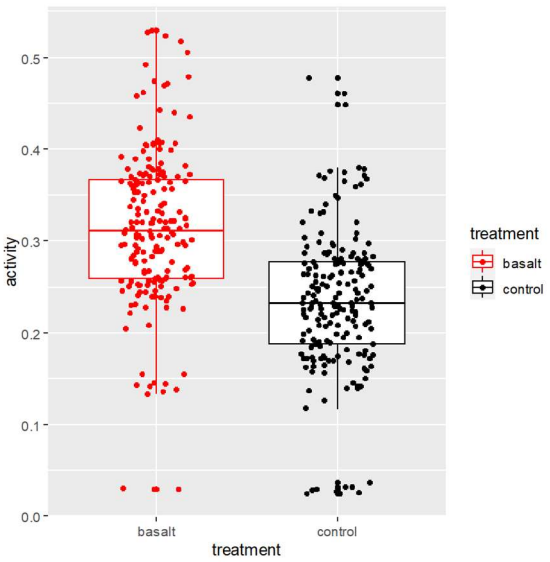

Figure S9: Effect of basalt amendment on microbial activity measured via the Fluorescein Diacetate (FDA) assay during one week at the end of May 2022. The effect of treatment was tested using a mixed model with the metabolic activity as dependant variable and treatment as independent variable, with unit as random variable. Values are expressed in µg of fluorescein released $mL^{-1}.h^{-1}$.

Macrocosm details

-location of the plot from which the macrocosms were extracted: 50° 59′ 02.1″ N, 5° 37′ 40.0″ E

-agricultural treatments:

27/10/2021: mustard was sown as a cover crop.

18/03/2022 (DOY 77): mineral NPK fertilisation was applied (100-80-140) (NH_4NO_3, K_2HPO_4, KNO_3).

25/03/2022 (DOY 85): basalt application in 3 units (incorporation on the top 20cm of soil)

Basalt composition: ((0.8 P_2O_5, 16 CaO, 11 MgO, 42 SiO_2, 3 K_2O, 11 Fe_2O_3, 1 Al_2O_3))

05/04/2022 (DOY 95): oat seeding (*Avena sativa*, cv SYMPHONY, 400 seeds/m2, 3-5 cm deep)

02/09/2022 (DOY 245): harvest (150 days of growth)

Note that the incorporation involved topsoil manipulation similar to tillage, and was not applied to the control units, but that tillage was anyway applied in all treatments (control and basalt) at the time of seeding, about 10 days later.

We did not add herbicides but weeded manually three times during growing season as *Rumex acetosella* L. colonized some macrocosms.