SUPPLEMENTARY MATERIALS FOR ARTICLE "Inclusion of biochar in a C-dynamics model based on observations from a 8 years field experiment", Pulcher et al. 2021.

Figure S1 shows the stages of the study divided in two parts: data collection and modelling. Data collection covers (1) the field experiment conducted by Ventura between 2012 and 2014, (2) field experiment of the present study, (3) laboratory analysis of the soil sampled in 2020. The data collected were entered into the RothC model to simulate the degradation of C-biochar in soil over time. The modelling part includes a (4) spin-up run, where climatic, soil and agricultural practices data are the average year condition of control plots between 2012 and 2014 reported by Ventura et al. (2015) and the regional environmental agency 'Arpa'; (5) the calibration of the RothC model with data of control plots collected between 2012 and 2014; (6) validation of the RothC model with data collected between 2012 and 2020 in control plots. After validated the RothC model, we (7) modified the standard RothC model with the inclusion of biochar (called BC-RothC) and (8) calibrated the BC-RothC model with data collected between 2012 and 2014 in biochar-treated plots; lastly, the modelling part includes (9) the validation of the BC-RothC model with data collected between 2012 and 2020 in biochar-treated plots.

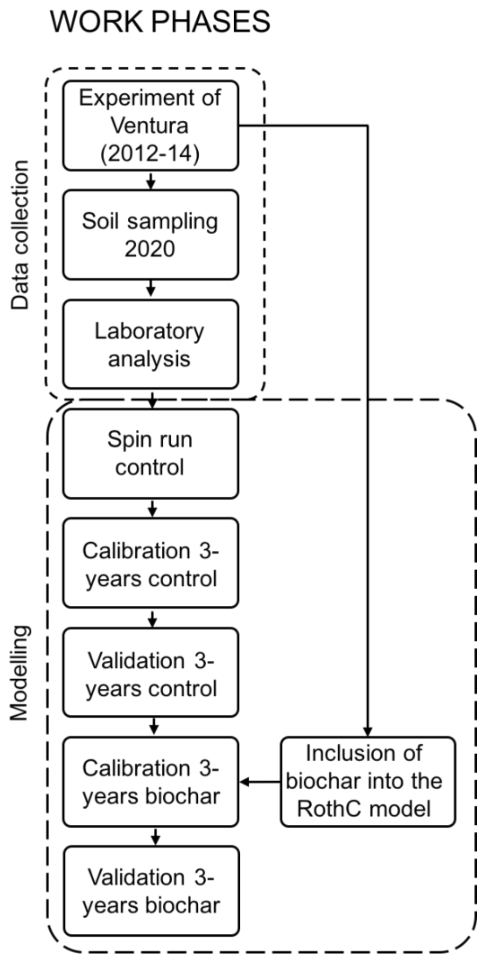

Figure S1. Workflow of the study.

Table S1. Climatic, soil and agricultural practices inputs required by the RothC model. Agricultural and climatic inputs are set on monthly basis, starting from January (month 1 of simulation) until December (month 12 of simulation).

RothC input		**Monthly input (Month=1:12)**	**Reference**
Climatic			
	Temperature (°C)	1.9; 3.31; 8.28; 12.4; 16.87; 21.216; 22.85; 21.99; 17.63; 12.62; 7.014; 2.37	Monthly average data from 2001 to 2020 by Arpa Piemonte
	Precipitation (mm)	46; 71.92; 83.89; 121.79; 162.9; 113.16; 98.73; 137.4; 117.75; 85.2; 203.96; 117.52	Monthly average data from 2001 to 2020 by Arpa Piemonte
	PET (mm)	18.46; 30.97; 64.84; 90.14; 134.53; 162.63; 166.04; 151.54; 102.03; 55.65; 25.4; 17.75	Monthly average calculated with FAO Penman-Monteith (Allen et al. 1998)
Soil			
	Reference depth (cm)	40	Depth of soil sampling (Ventura et al. 2015)
	Clay (%)	12.3	Ventura et al. 2015
	Bulk density	1.4	Ventura et al. 2015
Agricultural practices			
	C inputs (DPM/RPM, t C ha^{-1})	1.8; 1.8; 1.2; 2.19; 2.19; 2.19; 2.19; 2.25; 2.3; 2.22; 2.16; 2.4	Weighted average between DPM/RPM of grass (1.2) and grass (2.4)
	OCm (t C ha^{-1})	0; 0; 0.062; 0.362; 0.362; 0.362; 0.362; 0.515; 0.731; 0.431; 0.252; 0.02	Sum of above- and belowground inputs from grass (Zanotelli et al. 2013; Pausch and Kuzyakov 2018) and poplar (Ventura et al. 2019)
	Soil cover	0.6; 0.6; 0.6; 0.6; 0.6; 0.6; 0.6; 0.6; 0.6; 0.6; 0.6; 0.6	Direct observation during previous experimental activity (Ventura et al. 2015, 2019a)
	FYM	-	-
	Irrigation	-	-

Table S2. SOC stocks in control and biochar-treated plots, and C-biochar stock at 0-20 and 20-40 cm depths in 2013, 2015 and 2020. Values are reported as mean ± standard error among the treatments (n=4) for 2013 and 2015; and mean ± standard error among the samples (n=5) for 2020. The letters ‘a’ and ‘b’ indicate, respectively, a statistically significant or insignificantly result.

treatment	Control				Biochar	
	Native SOC stock (t C ha^{-1})				Biochar-C stock (t C ha^{-1})	
Sampling period (month/year)	0-20	20-40	0-20	20-40	0-20	20-40
1/2013	27.9 ± 0.23 a	28.1 ± 1.01 a	45.22 ± 6.6 b	38.2 ± 8.73 b	13.87 ± 5.96	-0.23 ± 0.95
3/2015	46.14 ± 3.2 a	34.2 ± 2.52 a	53.45 ± 3.6 b	39.26 ± 0.47 b	9.94 ± 3.51	0.69 ± 0.24
10/2020	32.6 ± 1.24 a	27.3 ± 0.93 a	46.13 ± 3.46 b	25.8 ± 0.9 a	8.47 ± 2.45	1.46 ± 0.3

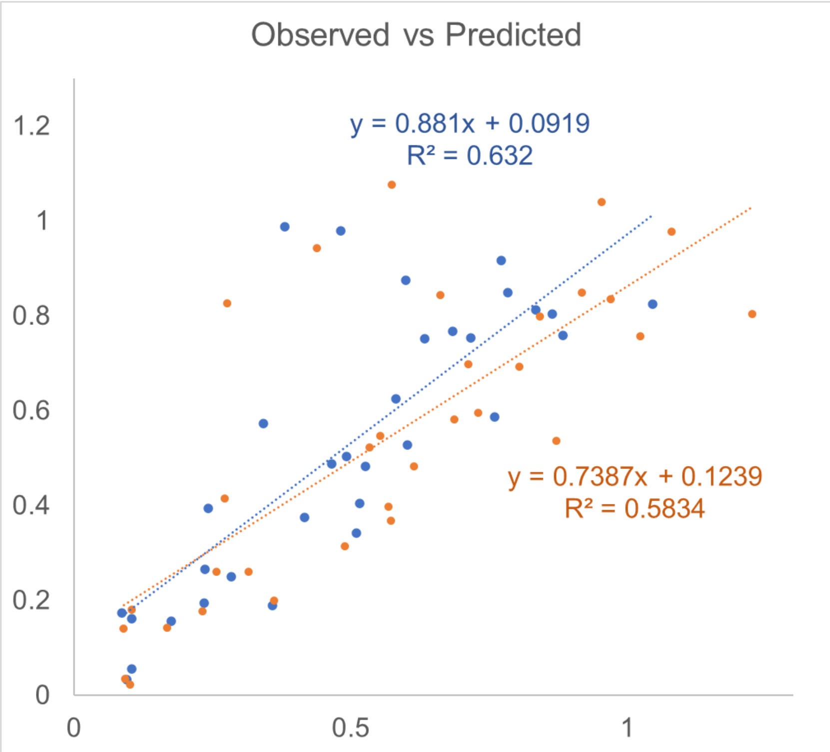

Figure S2. Model fit visualized as observed vs predicted values, for the data shown in Figure 2 in the main manuscript..

Sensitivity Analysis (OFAT)

Here we explored the response of the model BC-RothC, with all the same input for the model as detailed in the main article, changing only the main variables related to the biochar extension of RothC, k_{LAB} 4% and k_{REC} 96%. This is, essentially, a one factor at a time sensitivity analysis, with the results from the validated simulation for biochar as a baseline.

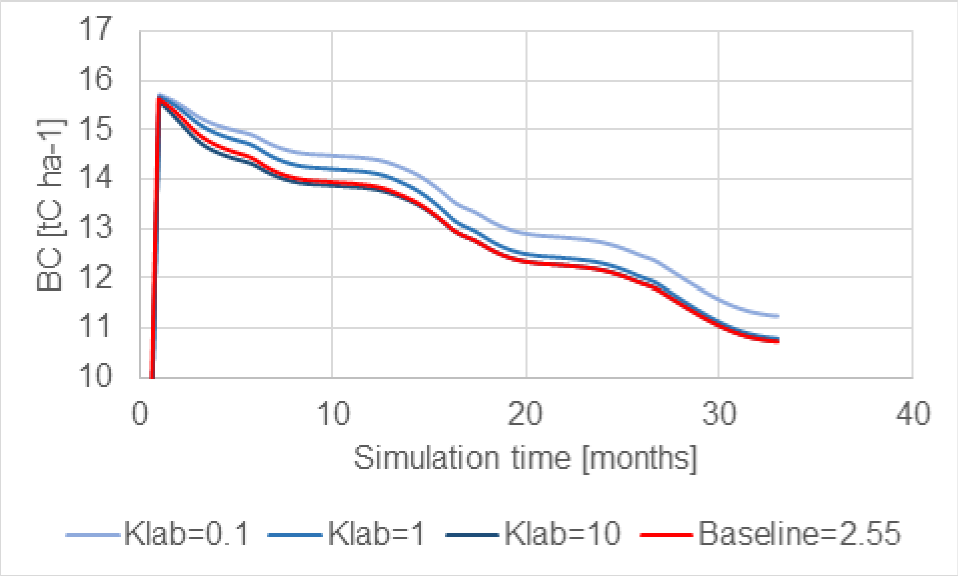

Figure S3. variation in biochar pool in BC-RothC, with respect to the baseline, with changing labile fraction degradation rate (Klab, yr-1).

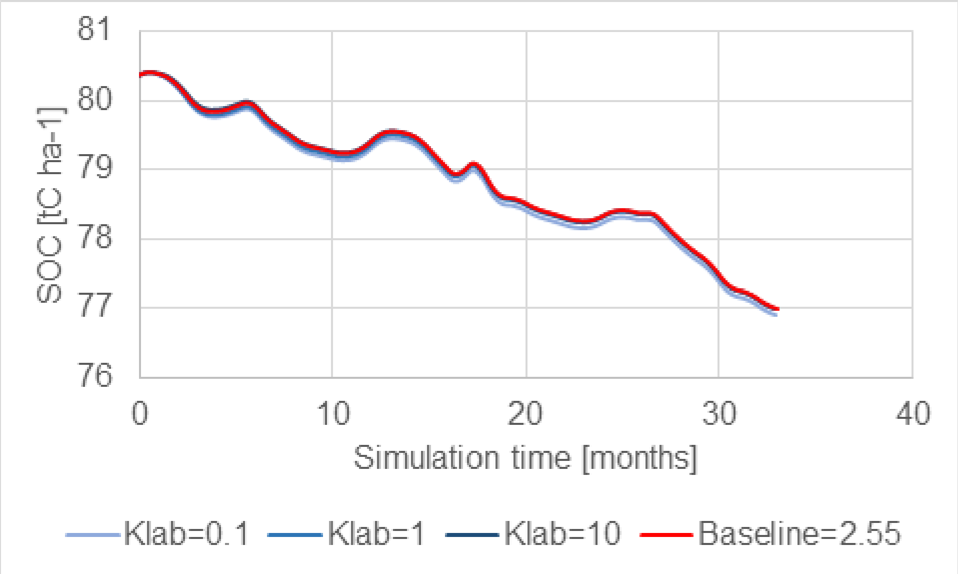

Figure S4. variation in SOC pool in BC-RothC, with respect to the baseline, with changing labile fraction degradation rate (Klab, yr-1).

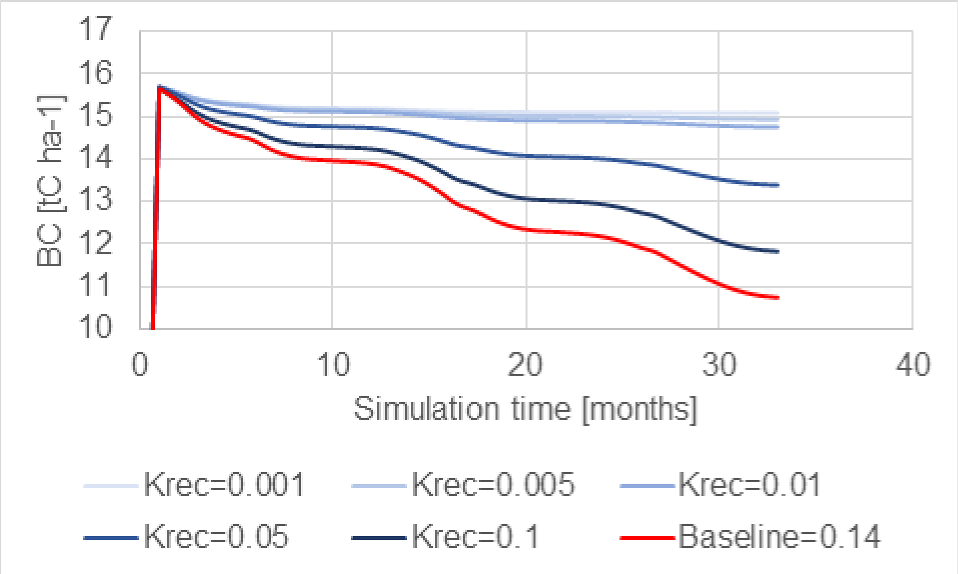

Figure S5. variation in biochar pool in BC-RothC, with respect to the baseline, with changing recalcitrant fraction degradation rate (Krec, yr-1).

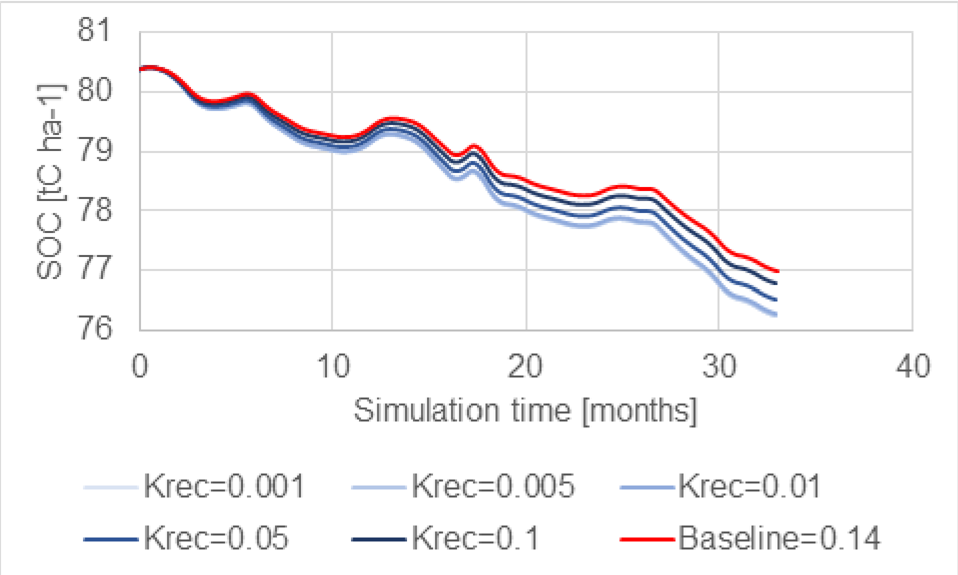

Figure S6. variation in SOC pool in BC-RothC, with respect to the baseline, with changing recalcitrant fraction degradation rate (Krec, yr-1).

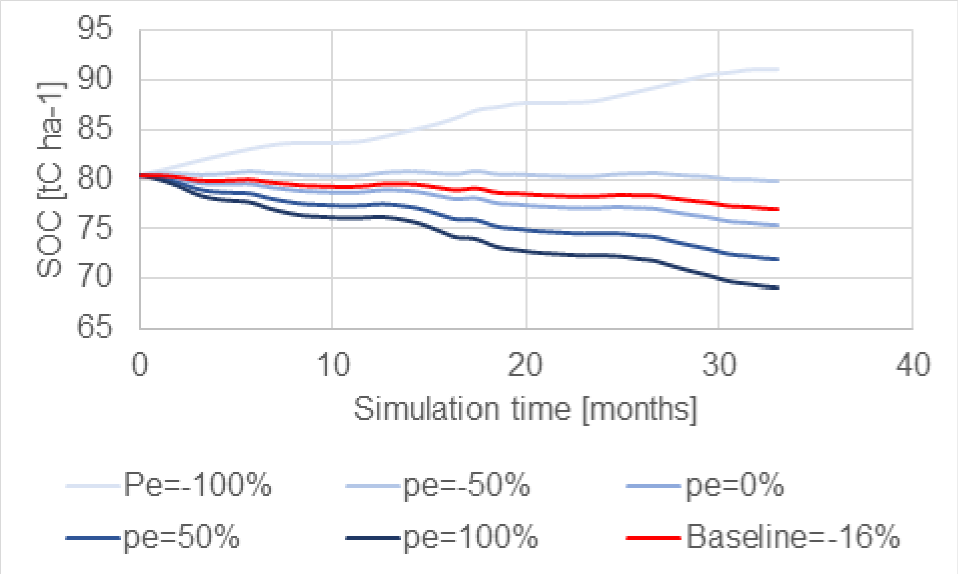

Figure S7. variation in SOC pool in BC-RothC, with respect to the baseline, with changing priming effect (pe, %). Negative pe means that SOC degradation is decreased, i.e. SOC is protected.

Figures S1 and S2 show that changing the degradation rate of the labile fraction of biochar (Klab), even by three orders of magnitude (from around 1 month to 10 years), has little effect on the amount of biochar that remains in the soil in the long run. This is to be expected due to the small fraction of labile biochar material in the study (4%). However, labile fraction for other biochars are usually in the same range, labile biochar being usually 5% of total biochar.

Figure S3 shows that the effect of changing the degradation rate of the recalcitrant fraction of biochar (Krec) has a large effect on the amount of biochar that remains in the soil in the long term (here, 3 years only), as expected. Changes are very large when Krec > 0.01 yr^{-1} (degradation time of 100 years). This is also to be expected, since the lower values will have an effect on longer simulation times, e.g. the difference between Krec 0.001 and 0.005 yr^{-1} will be visible only after more than 100 years. Figure S4 shows that changing Krec has little effect on SOC values. This is to be expected, due to the small value of the priming effect (-16%). It means that, when more biochar remains in the soil, less SOC is degraded per year.

Figure S5 shows the effect of changing the priming effect (pe) on SOC. A pe of -100% means that biochar completely protects SOC from degradation, resulting in a much larger amount of SOC in the soil after 3 years. Conversely, a pe of 100% means that biochar accelerates the degradation rate of SOC, doubling it and resulting in a much lower amount of SOC in the soil after 3 years. This appears to be, by far, the most important parameter of the model – and it appears to be almost the most uncertain, since the priming effect of biochar has been shown to be, in literature, sometimes positive, sometimes negative, with no understanding yet of the underlying process. Moreover, the priming effect has been shown to be either changing in time (Jiang et al. 2019) or stable (this study).

Jiang X, Tan X, Cheng J, Haddix ML, Cotrufo MF (2019) Interactions between aged biochar, fresh low molecular weight carbon and soil organic carbon after 3.5 years soil-biochar incubations. Geoderma 333:99–107. https://doi.org/10.1016/j.geoderma.2018.07.016