

## 1 Supplementary Information:

2 Supplementary Table 1: Information on experimental sites: Country, pair site number, location  
 3 (longitude and latitude), mean and standard deviation (n = 8) for soil texture fractions (Clay < 0.002  
 4 mm, Silt 0.002 - 0.063 mm, Sand 0.063 - 2 mm), pH, and CaCO<sub>3</sub> for the paired study sites with low  
 5 and high management intensity.

Country	Pair site	Longitude	Latitude	Intensity	Clay in %	Silt in %	Sand in %	pH	CaCO <sub>3</sub> in %
AT	1	47.898336	16.652335	low	16.3 ± 0.8	39.6 ± 1.0	44.1 ± 1.6	7.2 ± 0.1	2.1 ± 0.5
		47.898488	16.652602	high	15.6 ± 1.1	40.2 ± 1.6	44.2 ± 2.3	7.2 ± 0.0	1.5 ± 0.3
AT	2	47.929963	16.694447	low	10.1 ± 1.0	36.5 ± 2.7	53.4 ± 3.2	7.3 ± 0.0	8.9 ± 1.7
		47.930587	16.695285	high	9.3 ± 0.8	36.6 ± 1.6	54.1 ± 2.1	7.1 ± 0.1	* < 0.92
AT	3	48.060516	16.727051	low	17.9 ± 1.2	60.9 ± 2.2	21.2 ± 1.6	7.3 ± 0.0	15.0 ± 0.8
		48.060603	16.727111	high	17.9 ± 1.1	60.4 ± 2.6	21.6 ± 2.0	7.4 ± 0.0	15.6 ± 0.4
AT	4	48.072412	16.745491	low	13.7 ± 1.3	59.9 ± 1.5	26.4 ± 2.2	7.3 ± 0.1	13.1 ± 2.6
		48.072557	16.745196	high	16.1 ± 2.2	58.1 ± 1.5	25.8 ± 1.7	7.5 ± 0.1	14.5 ± 2.1
AT	5	48.092591	16.962723	low	9.9 ± 0.8	42.7 ± 1.2	47.5 ± 0.9	7.3 ± 0.0	12.6 ± 1.4
		48.092623	16.962255	high	14.5 ± 1.4	44.3 ± 2.5	41.3 ± 1.5	7.4 ± 0.0	13.8 ± 5.8
FR	6	47.247712	-0.421513	low	20.1 ± 1.7	43.9 ± 2.2	36.0 ± 3.7	6.3 ± 0.2	* < 0.92
		47.247936	-0.421859	high	19.7 ± 1.1	40.2 ± 1.1	40.2 ± 1.9	6.6 ± 0.2	* < 0.92
FR	7	47.255933	-0.364396	low	35.1 ± 0.7	21.1 ± 1.6	43.9 ± 2.1	6.7 ± 0.1	* < 0.92
		47.255617	-0.363963	high	33.1 ± 1.9	18.2 ± 1.3	48.7 ± 0.9	6.0 ± 0.3	* < 0.92
FR	8	47.235328	-0.397988	low	19.1 ± 1.1	36.6 ± 1.2	44.3 ± 0.9	6.1 ± 0.1	* < 0.92
		47.233581	-0.397928	high	16.4 ± 1.5	38.9 ± 1.2	44.7 ± 1.2	5.7 ± 0.4	* < 0.92
FR	9	47.278514	-0.548891	low	12.5 ± 0.9	38.0 ± 1.6	49.5 ± 1.4	7.0 ± 0.1	* < 0.92
		47.295077	-0.550784	high	12.6 ± 2.3	38.4 ± 1.8	48.9 ± 0.7	6.0 ± 0.2	* < 0.92
FR	10	47.299826	-0.574773	low	16.3 ± 1.8	35.3 ± 3.7	48.4 ± 4.4	6.6 ± 0.2	* < 0.92
		47.265903	-0.485607	high	17.1 ± 2.8	34.1 ± 1.3	48.8 ± 3.0	6.1 ± 0.2	* < 0.92
RO	11	46.322783	23.760733	low	45.8 ± 1.0	43.3 ± 1.2	10.9 ± 0.2	7.2 ± 0.2	* < 0.92
		46.320067	23.761783	high	46.5 ± 2.2	43.9 ± 1.2	9.6 ± 1.3	7.6 ± 0.0	5.1 ± 2.6
RO	12	46.170616	23.949183	low	24.5 ± 1.7	44.9 ± 0.4	30.6 ± 1.9	6.7 ± 0.3	* < 0.92
		46.170750	23.947983	high	23.7 ± 1.3	59.4 ± 2.2	16.9 ± 3.3	7.5 ± 0.1	2.3 ± 0.3
RO	13	46.193166	24.075016	low	44.6 ± 3.3	33.4 ± 2.4	22.1 ± 2.0	7.5 ± 0.0	7.1 ± 5.7
		46.1917333	24.074433	high	42.8 ± 0.9	42.1 ± 1.6	15.2 ± 1.8	7.6 ± 0.0	19.7 ± 2.7
RO	14	46.2244800	24.07818	low	45.3 ± 1.9	36.0 ± 1.1	18.7 ± 1.3	7.4 ± 0.1	3.4 ± 1.0
		46.2231833	24.07596	high	39.6 ± 0.7	52.5 ± 0.7	7.8 ± 0.3	6.3 ± 0.1	* < 0.92
ES	15	37.540450	-4.558066	low	40.0 ± 3.1	41.1 ± 2.0	18.9 ± 2.2	7.6 ± 0.1	50.6 ± 1.4
		37.558433	-4.558216	high	42.6 ± 1.3	41.5 ± 2.7	15.9 ± 1.7	7.6 ± 0.0	59.8 ± 0.6
ES	16	37.549033	-4.569383	low	33.6 ± 3.3	45.2 ± 6.4	21.2 ± 5.6	7.5 ± 0.0	70.3 ± 4.6
		37.548083	-4.584183	high	29.2 ± 1.1	46.4 ± 1.7	24.4 ± 1.7	7.5 ± 0.1	65.2 ± 1.0
ES	17	37.579700	-4.576650	low	30.3 ± 6.5	44.3 ± 6.4	25.4 ± 11.1	7.5 ± 0.1	57.9 ± 2.7
		37.520033	-4.644566	high	34.1 ± 1.3	41.8 ± 3.1	24.1 ± 2.6	7.6 ± 0.0	48.7 ± 1.9
ES	18	37.625750	-4.704650	low	8.8 ± 1.5	13.1 ± 1.1	78.1 ± 2.3	7.6 ± 0.1	16.7 ± 0.7
		37.652366	-4.715883	high	17.0 ± 1.9	25.8 ± 2.5	57.1 ± 1.3	7.7 ± 0.0	16.6 ± 2.5

\* 0.92 % as minimum CaCO<sub>3</sub> concentration to be detected

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8 Supplementary Table 2: Information on vineyard management: Country, pair site number,  
 9 management intensity, management system (permanent vegetation cover, temporal vegetation  
 10 cover with weed removal in spring, alternating tillage in every second inter-row, bare soil), number  
 11 of mechanical soil disturbances per year including soil management (e.g., with plow, cultivator,  
 12 rotary tiller) and weed control (e.g., harrow), organic farming, compost and manure (except green  
 13 manure) application, pruning residues application, and use of mineral fertilizers.

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Country	Pair site	Intensity	System indicator	Soil disturbances	organic	Compost, manure	Pruning residues	Mineral Fertilizer
AT	1	low	permanent, mulched	0	no	no	no	no
		high	alternating, mechanical	2-4	no	no	no	yes
AT	2	low	permanent, mulched	0	no	no	no	yes
		high	alternating, mechanical	0.33-0.5	yes	yes	no	no
AT	3	low	permanent, mulched	0	no	no	no	yes
		high	alternating, mechanical	0.25-0.5	no	no	no	yes
AT	4	low	permanent, mulched	0	no	no	no	no
		high	alternating, mechanical	0.33-0.5	no	yes	yes	yes
AT	5	low	permanent, mulched	0	yes	no	no	no
		high	alternating, mechanical	4	no	no	no	yes
FR	6	low	permanent, mulched	0	no	no	yes	no
		high	bare soil, chemical	0	no	no	yes	no
FR	7	low	permanent, mulched	0	no	yes	yes	yes
		high	bare soil, chemical	0	no	yes	yes	yes
FR	8	low	permanent, mulched	0	no	no	yes	no
		high	bare soil, chemical	0	no	no	yes	no
FR	9	low	permanent, mulched	0	no	no	yes	no
		high	alternating, chemical	0	no	no	yes	no
FR	10	low	permanent, mechanical	0.5	no	yes	yes	no
		high	bare soil, chem./mech.	0.5	no	no	yes	no
RO	11	low	alternating, mechanical	0.5	no	no	yes	yes
		high	bare soil, mechanical	2-3	no	no	yes	yes
RO	12	low	alternating, mechanical	0.5	no	no	yes	yes
		high	bare soil, mechanical	2-3	no	no	yes	yes
RO	13	low	alternating, mechanical	3-4	no	no	yes	yes
		high	bare soil, mechanical	3-4	no	no	yes	yes
RO	14	low	permanent, mulched	0	no	no	yes	yes
		high	bare soil, mechanical	6	yes	no	yes	no
ES	15	low	permanent, mulched	0-1	yes	no	yes	no
		high	bare soil, mechanical	1-3	no	no	yes	yes
ES	16	low	temporal, mech./chem.	2-3	no	yes	yes	yes
		high	bare soil, mechanical	1-3	no	yes	yes	yes
ES	17	low	temporal, mech./chem.	1-3	no	yes	yes	yes
		high	bare soil, mechanical	2-4	no	no	yes	yes
ES	18	low	temporal, mech./chem.	1-3	no	yes	yes	yes
		high	bare soil, mechanical	2-4	no	no	no	yes

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16 Supplementary Table 3: Soil Hydraulic (Van Genuchten model) Parameters determined from the  
 17 water-retention curve based on undisturbed soil samples for numeric modelling the effects of

18 different soil management.  $k_{\text{sat}}$  is saturated conductivity,  $\alpha$  is a shape parameter related to the  
 19 inverse of the air entry suction,  $n$  is a shape parameter for the pore size distribution,  $\Theta_r$  and  $\Theta_s$  are  
 20 residual and saturated water content, and  $l$  is a tortuosity parameter in the conductivity function.

Country	Intensity	$k_{\text{sat}}$ cm min <sup>-1</sup>	$\alpha$ cm <sup>-1</sup>	$n$ (-)	$\Theta_r$ g g <sup>-1</sup>	$\Theta_s$ g g <sup>-1</sup>	$l$ (-)
AT	low	1.10	0.12	1.47	0.11	0.48	0.65
	high	1.06	0.07	2.12	0.10	0.47	0.65
FR	low	0.85	0.07	1.84	0.08	0.43	0.62
	high	0.48	0.05	1.62	0.11	0.39	0.51
RO	low	0.70	0.08	1.89	0.25	0.47	0.58
	high	0.48	0.06	2.68	0.20	0.46	0.51
ES	low	0.63	0.03	3.18	0.10	0.47	0.55
	high	0.42	0.05	2.41	0.12	0.50	0.49

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22 Supplementary Table 4: Soil structure properties: Country, pair site number, management intensity,  
 23 means and standard deviations of Total Organic Carbon (TOC) in %, of bulk density (BD) in g cm<sup>3</sup>, and  
 24 of Percolation Stability (PS) in ml 10 min<sup>-1</sup>. Significance of the difference based on the two-sample t-  
 25 test or Welch test for independent samples. Significant differences are indicated with bold font.

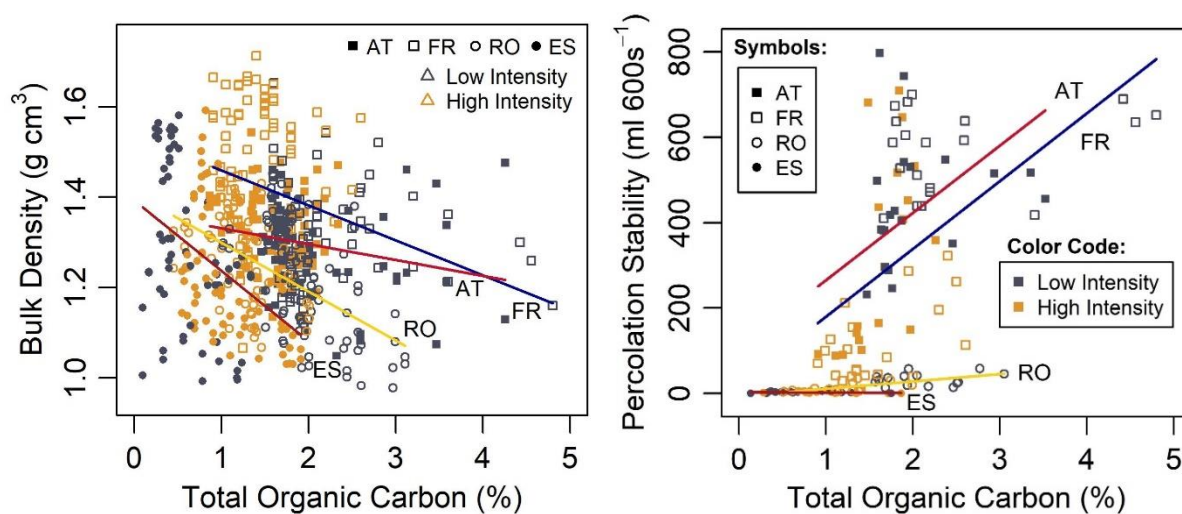
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Country	Pair site	Intensity	TOC	BD	PS
AT	1	low	<b>1.69 ± 0.09</b>	1.36 ± 0.06	<b>332.14 ± 112.71</b>
		high	<b>1.44 ± 0.15</b>	1.39 ± 0.07	<b>137.60 ± 29.43</b>
	2	low	<b>3.05 ± 0.79</b>	1.30 ± 0.12	509.27 ± 38.72
		high	<b>2.00 ± 0.22</b>	1.36 ± 0.09	453.92 ± 84.35
	3	low	1.72 ± 0.16	1.27 ± 0.05	585.79 ± 214.69
		high	1.80 ± 0.18	1.25 ± 0.05	333.20 ± 141.40
	4	low	<b>1.75 ± 0.15</b>	<b>1.27 ± 0.07</b>	<b>398.78 ± 21.80</b>
		high	<b>1.14 ± 0.19</b>	<b>1.33 ± 0.06</b>	<b>90.29 ± 1.96</b>
	5	low	1.95 ± 0.39	<b>1.21 ± 0.08</b>	<b>695.14 ± 40.68</b>
		high	1.78 ± 0.19	<b>1.28 ± 0.06</b>	<b>413.87 ± 149.26</b>
FR	6	low	<b>2.56 ± 0.64</b>	<b>1.39 ± 0.13</b>	<b>520.61 ± 108.71</b>
		high	<b>1.81 ± 0.23</b>	<b>1.52 ± 0.09</b>	<b>113.50 ± 117.19</b>
	7	low	<b>4.09 ± 1.02</b>	<b>1.28 ± 0.10</b>	<b>642.21 ± 40.18</b>
		high	<b>2.26 ± 0.44</b>	<b>1.48 ± 0.12</b>	<b>223.49 ± 89.57</b>
	8	low	<b>2.08 ± 0.37</b>	<b>1.36 ± 0.07</b>	<b>475.97 ± 29.49</b>
		high	<b>1.36 ± 0.13</b>	<b>1.62 ± 0.05</b>	<b>47.76 ± 7.97</b>
	9	low	<b>1.91 ± 0.08</b>	<b>1.20 ± 0.06</b>	<b>665.27 ± 41.91</b>
		high	<b>1.24 ± 0.05</b>	<b>1.30 ± 0.09</b>	<b>124.98 ± 77.43</b>
	10	low	<b>1.77 ± 0.08</b>	<b>1.29 ± 0.08</b>	<b>540.46 ± 97.43</b>
		high	<b>1.01 ± 0.09</b>	<b>1.51 ± 0.09</b>	<b>84.98 ± 36.67</b>
RO	11	low	<b>1.91 ± 0.13</b>	<b>1.13 ± 0.07</b>	38.89 ± 16.05
		high	<b>1.60 ± 0.33</b>	<b>1.24 ± 0.08</b>	27.40 ± 6.69
	12	low	<b>1.67 ± 0.16</b>	1.37 ± 0.06	<b>34.33 ± 6.31</b>
		high	<b>1.15 ± 0.14</b>	1.38 ± 0.04	<b>6.59 ± 1.49</b>
	13	low	<b>1.85 ± 0.58</b>	1.24 ± 0.09	12.95 ± 3.66
		high	<b>0.76 ± 0.23</b>	1.27 ± 0.07	8.28 ± 3.46
14	low	<b>2.71 ± 0.27</b>	<b>1.07 ± 0.07</b>	<b>38.74 ± 16.27</b>	

	high	<b>1.37 ± 0.05</b>	<b>1.16 ± 0.06</b>	<b>7.31 ± 2.28</b>
15	low	1.25 ± 0.34	1.22 ± 0.10	3.83 ± 3.48
	high	1.07 ± 0.21	1.17 ± 0.11	1.81 ± 1.17
16	low	<b>0.58 ± 0.43</b>	1.11 ± 0.11	1.36 ± 1.58
	high	<b>1.67 ± 0.21</b>	1.09 ± 0.05	0.00 ± 0.00
17	low	<b>0.50 ± 0.18</b>	<b>1.30 ± 0.10</b>	1.92 ± 2.25
	high	<b>0.71 ± 0.13</b>	<b>1.21 ± 0.05</b>	5.08 ± 1.33
18	low	<b>0.38 ± 0.10</b>	<b>1.53 ± 0.03</b>	<b>3.20 ± 0.72</b>
	high	<b>0.82 ± 0.08</b>	<b>1.45 ± 0.06</b>	<b>1.66 ± 0.89</b>

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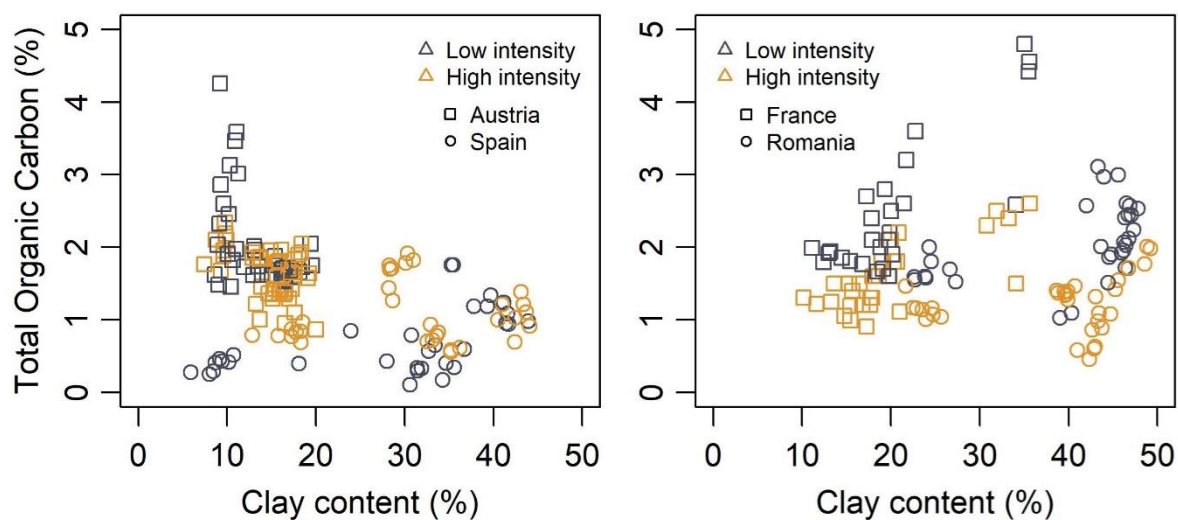
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30 Supplementary Figure 1: Scatter plot of Bulk Density (BD) in g cm<sup>-3</sup> and Percolation Stability (PS) in ml  
 31 10 min<sup>-1</sup> against Total Organic Carbon (TOC) in % based on soil surface samples for the low  
 32 management intensity and high management intensity sites. Quality measure R<sup>2</sup> for BD/PS: Austria  
 33 0.05/0.17. France 0.12/0.34. Romania 0.28/0.42. Spain 0.19/0.09.

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36 Supplementary Figure 2: Scatter plots of Total Organic Carbon (TOC) contents in the soil surface for  
37 the Low management intensity and high management intensity sites grouped by country.

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40 Supplementary information on the HYDRUS-1D calculation and used design rainfall events:

41 We calculated soil water fluxes based on the van Genuchten -Mualem single porosity model by use of  
42 the HYDRUS-1D software package with soil hydraulic properties shown in Supplementary Table 3.  
43 The three design rainfalls with duration of 15-minutes periods had rainfall amounts of 11.3, 20.0, and  
44 37.8 mm. These design rainfalls were used for all locations to ensure comparability. After two days,  
45 we compared water fluxes and water retention at one observation node below the topsoil layer at an  
46 average tillage depth of 15 cm for each designed rainfall event. Initial moisture conditions were set  
47 according to measured conditions during sampling in spring close to field capacity with -330 hPa.  
48 Root water uptake, interception, or evapotranspiration were not considered when comparing soil  
49 hydraulic characteristics between low-intensive management with cover crops and high-intensive  
50 management without cover crops. The upper boundary was set to atmospheric boundary conditions  
51 with a surface layer and maximum ponding of 2 cm before surface runoff was initiated to consider  
52 surface roughness and lower hydraulic conductivity at the start of rain. The lower boundary  
53 conditions in the vadose zone were set as free drainage.

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