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6
7 **Accurate evaluation of the Birch effect requires continuous CO₂ measurements and**
8 **relevant controls**

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18 **Highlights**

- 19 • Daily soil organic carbon mineralization rate increased with soil moisture
20 • A control scenario with water content equal to the average content in dry-wet cycles is suitable
21 • There is no effect of dry-wet cycles on net CO₂ emission in cultivated Luvisols
22 • Not accounting the CO₂ emissions in the drying phase may overestimate the dry-wet cycles effect
23

24 **Abstract**

25 The influence of dry-wet cycles (DWC) on soil organic carbon (SOC) decomposition is still
26 debated given the somehow controversial results observed in the literature. The objective of this study
27 was to evaluate the effects of DWC on SOC mineralization relative to various moisture controls in 7
28 treatments from two long-term French field experiments presenting contrasted SOC concentrations. A
29 laboratory incubation was conducted for 97 days to quantify CO₂ emissions upon four soil moisture
30 scenarios: continuously wet scenario at pF 1.5 (WET), continuously moderate wet scenario at pF 2.5
31 (MWET), continuously dry scenario at pF 4.2 (DRY) and dry-wet cycles (DWC) between pF 1.5 and
32 4.2 . Each cycle contained two phases, 10 days of drying phase, followed by 7 days of moist phase after
33 rewetting. The drying phase consisted of adding silica gel to the incubation jars to absorb water in the
34 soil and then gradually drying the soil We also calculated the SOC mineralization that would correspond
35 to the average water content in DWC (mean_DWC). Our results showed that across all treatments the
36 daily carbon mineralization rate increased with soil moisture (WET>MWET>DRY). In DWC scenario,

37 mineralization rates fluctuated with the changes in soil moisture. As soils dried, daily mineralization
38 rates decreased and the subsequent soil rewetting, to pF 1.5, caused a rapid mineralization flush or "Birch
39 effect". However, these flushes did not compensate for the low mineralization rates in the drying phase
40 as the cumulative mineralization was not higher in the DWC scenario compared to the mean_DWC
41 which was the scenario with equivalent water content as the DWC. We also observed that not accounting
42 the CO₂ emissions in the drying phase, could lead to an overestimation of the effect of DWC. We
43 recommend to measure continuously the soil respiration during dry-wet experiments and to compare the
44 CO₂ emitted in DWC with a control that has a water content equivalent to the average water content in
45 DWC. In addition, we questioned the importance of the effect of DWC on overall soil respiration.

46

47 *Keywords: Dry-wet cycles, carbon mineralization, soil moisture, soil organic carbon.*

48

49

50 **Short communication**

51

52 Soil moisture, in addition to temperature, is a major environmental factor controlling soil
53 organic carbon (SOC) mineralization (Davidson et al., 1998, Davidson et al., 2006, Luo et al., 2016,
54 Sierra et al., 2015). In general, SOC mineralization and the subsequent release of CO₂ from soil respond
55 parabolically to transitional changes in soil moisture (Moyano et al., 2012) as follows: under low soil
56 moisture conditions, SOC mineralization is decreased because of reduction of substrate availability and
57 of microbial activity; under increased moisture conditions, substrate availability and microbial activity
58 are enhanced. However, heterotrophic soil respiration is diminished by reduced oxygen diffusivity under
59 saturated soil moisture conditions. This parabolic relationship between soil organic matter (SOM)
60 decomposition and soil moisture has been well documented and incorporated into a number of models
61 simulating SOM decomposition and the global carbon cycle (Davidson et al., 1998, Davidson et al.,
62 2006, Luo et al., 2016, Sierra et al., 2015).

63

64 Climate change has been found to exacerbate terrestrial water evaporation and increase
65 atmospheric moisture content, resulting in frequent droughts and heavy precipitation events (Dai, 2013,
66 Donat et al., 2016). Under climate change, many surface soils are likely to experience more frequent
67 and/or intense rewetting in response to rainfall events that occur following dry conditions (Borken and
68 Matzner, 2009). Fluctuations in soil heterotrophic activity in response to changes in soil moisture are
69 ubiquitous (Manzoni et al., 2012). It is recognized that droughts tend to decrease biological activity, and
70 the subsequent precipitation would lead to "pulses" of CO₂ emissions to the atmosphere (Birch, 1958).
71 These dry-wet events can influence several processes in soils, including soil aggregation (Denef et al.,
72 2001, Cosentino et al., 2006), microbial activity and community structure (Tiemann and Billings, 2011,
73 Evans and Wallenstein, 2012), and SOC mineralization (Birch, 1958, Fierer and Schimel, 2003, Borken
74 and Matzner, 2009, Zhang et al., 2020). The effect of dry-wet cycles on cumulative SOC mineralization

75 remains however controverted in literature (Zhang et al., 2020). Results are very heterogeneous across
76 studies, because of the diversity of drying-rewetting scenario considered, but likely also because of
77 methodological issues. Indeed, there are methodological artefacts, as a number of studies do not measure
78 CO₂ emissions during the drying phase (e.g., Beare et al., 2009, Chow et al., 2006, Kaisermann et al.,
79 2013, 2015), while others do so systematically (e.g., Miller et al., 2005, Mikha et al., 2005, Harrison-
80 Kirk et al., 2013, Shi and Marschner, 2014, 2017, Yemadje et al., 2017). This makes the interpretation
81 of results more complex, because the carbon budget is not complete in such studies. Although flushes
82 of CO₂ emission have been widely reported (Birch effect), it is essential to understand whether the
83 alternance of drying and rewetting conditions leads to a net increase of the CO₂ emitted by soils.

84
85 In the present study, we compared the SOC mineralization in soil subjected to dry-wet cycles
86 (DWC) and kept at various constant water contents. Soils were sampled from two French long-term
87 field experiments on Luvisols of similar texture situated both in Versailles' area with a mean annual
88 temperature of 11.6 °C and precipitation of 633 mm during the study period, but under contrasting
89 agricultural practices, in order to encompass a diversity of SOC contents. At the "La Cage" field
90 experiment (48°48'N, 2°08'E) we considered 3 treatments: conservation agriculture (CA), organic
91 agriculture (ORG) and conventional agriculture (CON-LC), which are presented in detail along with
92 crop rotations, soil management and fertilization in Autret et al. (2016). At the "QualiAgro" experiment
93 (48°52'N, 1°57'E), the soil has been cultivated for 21 years with a conventional wheat-maize rotation
94 and organic waste products (OWPs) are applied every 2 years as presented in detail in Peltre et al. (2012)
95 and Paetsch et al. (2016). On this site we considered three organic treatments: residual municipal solid
96 waste (MSW) composts, biowaste composts (BIOW) and farmyard manure (FYM) and one control
97 treatment without organic inputs (CON-QA). At both sites, four replicate plots were available per
98 treatment. From each plot, 3 sub-samples were taken, thoroughly mixed and combined into one sample.
99 Samples were sieved to 4 mm, homogenized, plant material was removed and stored at 4 °C before
100 incubation experiences.

101
102 Based on continuous measurements of soil moisture at the QualiAgro experiment during three
103 consecutive years, we selected -0.015 MPa (pF 1.5) as the upper soil moisture value and -1.6 MPa (pF
104 4.2) as the lowest soil moisture condition. Indeed, these measurements showed that, at 20 cm depth, the
105 soils never dried out beyond pF 4.2, even in summer (see Fig. S3). The choice of pF 4.2 is therefore
106 reasonable for an extreme drying scenario in these soils. A prior experiment was conducted to determine
107 the time required to dry the soil from a matric potential of -0.015 MPa (pF 1.5) to -1.6 MPa (pF 4.2)
108 with silica gel. Gravimetric soil water content (w) was determined by weight loss at 105 °C for 48 hours.
109 For each soil sample, we made cylinders of soil with soil aggregates < 4 mm at a bulk density of 1.3
110 g.cm⁻³. Based on the initial water content, these soil cylinders were gradually adjusted to pF 2.5 by
111 adding water with a pasteur pipette. Then, these soil cylinders were mounted in 1L jars containing 15

112 mL of water at the bottom to stabilize the moisture. The jars were sealed and the whole set was placed
 113 in the incubator at 20 °C for a one-week pre-incubation. To evaluate the dry-wet cycles (DWC) effect
 114 on SOC mineralization, 4 scenarios were performed and applied at 20 °C: a continuously wet scenario
 115 at pF 1.5 (WET); a continuously moderate wet scenario at pF 2.5 (MWET); a continuously dry scenario
 116 at pF 4.2 (DRY) and a scenario with five subsequent dry-wet cycles (DWC). To reach pF 1.5 after pre-
 117 incubating at pF 2.5, we added deionized water using a pasteur pipette to replicates dedicated to the
 118 WET scenario. For replicates dedicated to MWET scenario (pF 2.5), we checked if the soil moisture
 119 corresponded to pF 2.5. For the replicates dedicated to the DRY scenario, we introduced 50 g of silica-
 120 gel during the pre-incubation phase to dry the soil. As soon as the moisture level corresponding to pF
 121 4.2 was reached, we removed the silica-gel from the jars. For the DWC scenario, five dry-wet cycles
 122 were implemented during the experimental period (97 d). Each cycle contained two phases: 10 days of
 123 drying phase, followed by 7 days of moist phase after rewetting. The drying phase consisted of adding
 124 silica gel to the incubation jars to absorb ambient moisture and hence gradually drying the soil (Fig. 1b).
 125 50 g of silica gel were added to each jar and changed after 6 days when the jars were vented after
 126 measuring the CO₂ concentration in the headspace by micro-chromatography. At the end of the drying
 127 period, rapid rewetting was performed by adding deionized water (the amount of water needed to reach
 128 pF 1.5) with a pasteur pipette (Fig. 1b). The same procedure was repeated for 5 times to simulate the
 129 dry-wet cycles events in the different treatments. We measured soil organic carbon (SOC) mineralization
 130 over time in both experiments non-destructively using a gas micro-chromatograph (μGC 490; Agilent
 131 Technologie; USA).

132 The CO₂ measurements on the constant moisture scenarios allowed us to establish a relationship
 133 between water content and daily mineralization rate. Based on this relationship, we reconstructed the
 134 theoretical value of carbon mineralization corresponding to an average water content measured in the
 135 dry-wet cycles during the experiment (Fig. 2b). This theoretical value is not often used in dry-wet cycle
 136 studies. Thus, we called this theoretical value “mean_DWC”. Weighing the mass of the cylinders at each
 137 CO₂ measurement allowed us to calculate this average water content in the dry-wet cycles (w_{DWC}). To
 138 do this, we first calculated the average amount of water lost (m_{lost}) per day when silica gel is introduced
 139 during the drying phase after 6 days and last 4 days using this formula:

$$140 \quad m_{lost} (g H_2O) = \frac{\left(\frac{(m_{d0} - m_{d6})}{6} + \frac{(m_{d6} - m_{d10})}{4} \right)}{2} \quad (2), \text{ with } m_{lost} \text{ the average mass of water lost}$$

141 per day during the drying phase, m_{d0} represents the mass of the soil cylinder at pF 1.5, m_{d6} the mass of
 142 the soil cylinder after 6 days of drying and m_{d10} the soil cylinder mass after the last 4 days of drying.
 143 Once this mass of water lost during the drying phase was known, we calculated the water content
 144 corresponding to each day via the following formula: $w_{d(g H_2O, g^{-1} soil)} = (w_{d-1} - m_{lost})$ (3), with w_d
 145 the water content on day d and w_{d-1} the water content on day d-1. The water content in the wetting phase

146 after rewetting being constant, the average water content in the dry-wet cycles was obtained with the
147 following formula: $W_{DWC}(\text{g H}_2\text{O.g}^{-1}\text{soil}) = \frac{w_{d0}+w_{d1}+\dots+W_{d17}}{17}$ (4). The values of W_{DWC} are
148 shown in Fig. S2 for different treatments. Given this average water content (W_{DWC}), we used the
149 relationship between water content and daily mineralization rate stated above to determine the
150 mineralization rate and cumulative mineralization corresponding to the average moisture value
151 (mean_DWC) for all treatments (Fig. 2b).

152 All data were tested for normality and homogeneity of variance. Log-transformation was
153 applied, if the transformation improved the normality and variance substantially. A one-way ANOVA
154 and Tukey's test was used to detect the differences in amount of SOC mineralized values among soil
155 moisture within each treatment. All statistical analyses were completed in R (version 4.0.2).

156 At the end of the incubations, our results showed that across all treatments, the daily carbon
157 mineralization rate increased with soil moisture content: WET>MWET >DRY (Fig. 2a and Fig. S1). In
158 DWC scenario, mineralization rates fluctuated with changes in soil moisture. As soils dried, daily
159 mineralization rates decreased and were lower 10 days after drying started, corresponding to the time
160 when soil had reached a matric potential of pF 4.2 (0.09 to 0.13 g.H₂O.g⁻¹ soil depending on the
161 treatments, Fig. S2). Throughout the incubation, the SOC mineralization rate significantly decreased in
162 all moisture scenarios whatever the field treatment (Fig. 2a and Fig. S1). During the drying period, the
163 SOC mineralization rate of DWC scenario significantly decreased, compared with WET and MWET
164 scenarios, but when soil reached pF 4.2 its mineralization rate was similar to the mineralization rate
165 observed on the DRY scenario. These results could be explained by the fact that the diffusive transport
166 of substrates and extracellular enzymes, as well as the active and passive mobility of microorganisms
167 slow down with decreasing water potential and abating thickness and discontinuity of the water film
168 (Broken and Matzner, 2009) which in turns decreases the accessibility of substrates to decomposers
169 (Moyano et al., 2013). At a matric potential of -1.6 MPa (pF 4.2) microbial activity was found to be
170 reduced (Franzluebbers et al., 1994, Pulleman and Tietema, 1999), which could also be due to a
171 reduction in microbial populations (Schimel et al., 1999, Butterly et al., 2009) caused by drying events.

172
173 A subsequent rewetting of soils to pF 1.5 in this study caused a rapid mineralization flush (Fig.
174 2a) or "Birch effect" (Birch, 1958). In the literature, two mechanisms are considered to explain this
175 phenomenon: the first is physiological and is linked to the consumption of intracellular solutes after the
176 death of microbial cells during the drying event; the second is physical and is linked to the exposure of
177 previously protected SOC following the destruction of aggregates (Denef et al., 2001, Fierer and
178 Schimel, 2003, Bailey et al., 2019). Also, the rewetting leads to the re-establishment of hydrological
179 connectivity between substrates and microorganisms (Manzoni et al., 2016). We found in the present
180 study that the mineralization flushes after rewetting did not exceed the mineralization rates in the WET,

181 MWET and mean_DWC scenarios (Fig. 2a and Fig. S1). These results suggest that the soils rewetting
182 did not lead to additional carbon mineralization as expected. In addition, we observed that when soils
183 are exposed to multiple DWC, the CO₂ flush after rewetting generally decreased and stabilized with
184 increasing DWC number (Fig. 2a and Fig. S1). This result is in partial agreement with those of Baumann
185 and Marschner (2013), who observed a decrease and even disappearance of CO₂ flushes with increasing
186 DWC number. This may be due to depletion of available substrates (Shi and Marschner, 2017), to a
187 change in microbial community composition (Fierer and Schimel, 2003), and/or the fact that soil
188 aggregates are no longer disturbed (Denef et al., 2001).

189
190 Although CO₂ flushes were observed in all treatments after the rewetting phase, these flushes
191 were not enough to compensate the low mineralization rates recorded in the drying phase on a
192 cumulative basis, when considering MWET as a continuously wet control (Table. 1). This result is
193 consistent with those obtained by Mikha et al. (2005) and Zhang et al. (2020): dry-wet cycles do not
194 lead to a net increase in emitted CO₂. However, the effect of dry-wet cycles on cumulative soil carbon
195 mineralization is much debated in the literature. Some studies found a stimulatory effect (Fierer et
196 Schimel, 2002, 2003, Miller et al., 2005, Butterly et al., 2009), while others found an inhibitory effect
197 (Mikha et al., 2005, Guo et al., 2012, Harrison-Kirk et al., 2013, Kaisermann et al., 2013, 2015, Yamadje
198 et al., 2017, Rahman et al., 2018) or similar effect (Jager and Bruins, 1975; Degens and Sparling, 1995,
199 Priemé and Christensen, 2001, Denef et al., 2001, Baumann and Marschner, 2013) of dry-wet cycles on
200 cumulative soil organic carbon mineralization. Zhang et al. (2020) in their meta-analysis showed that,
201 on average, dry-wet-cycles stimulated cumulative carbon mineralization by 72% compared to the dry
202 control and inhibited cumulative carbon mineralization by 25% compared to the wet control, but had a
203 minor effect compared to a medium wet control. The similar cumulative mineralization between the
204 DWC and the medium wet control observed by Zhang et al. (2020), convinced us to reconstitute in our
205 study a control whose water content was equivalent to the average water content in the dry-wet cycles.

206
207 When comparing the carbon mineralization in the DWC versus the corresponding
208 mineralization at equivalent water content (mean_DWC), we found that DWC led to a similar cumulated
209 mineralization for some treatments (CON-LC and CA) versus significantly less cumulated
210 mineralization for other treatments (ORG, CON-QA, MSW, FYM and BIOW) (Fig. 3). The average
211 water content in the DWC was generally lower than the water content corresponding to pF 1.5 and pF
212 2.5 (see Fig. S2). These results indicate that the observed effect of DWC on carbon mineralization
213 depends much on the water content of the selected control scenario as discussed by Guo et al. (2012). It
214 is relevant to have a control with a water content equivalent to the average water content in the dry-wet
215 cycles. The recent study conducted by Zhang et al. (2022) considered a control scenario with a water
216 content equivalent to the average water content in the dry-wet cycles (33.25% WHC) and observed that
217 the flushes of mineralization after rewetting compensated the low mineralization in the drying phase.

218 Also, the previous study by Guo et al. (2012) using a range of controls with different water field pore
219 space (WFPS) values (30, 45, 60, 75, 90% WFPS), demonstrated that cumulated carbon mineralization
220 in the dry-wet cycles was similar to cumulated carbon mineralization in the control whose water content
221 (60% WFPS) was equivalent to the average water content in the dry-wet cycles (63% WFPS). Next to
222 the selection of an adequate moisture control, the carbon balance can be questioned, as it will depend
223 on whether respiration measurements are performed on both drying and rewetting phases or not.

224

225 While a number of studies only account the CO₂ fluxes measured in the rewetting phase to
226 evaluate the effect of dry-wet cycles (e.g., Beare et al., 2009, Chow et al., 2006, Degens and Sparling,
227 1995; Kaisermann et al., 2013, 2015, Li et al., 2010, 2011, Shah and Gaebler., 2016, Tiemann et al.,
228 2011), the experimental design implemented in our study allowed for continuous CO₂ measurement. We
229 therefore sought to evaluate to which extent measuring evolved CO₂ only during the DWC wet phases
230 versus continuously affected the results. The results in Table. 1 show that when considering continuous
231 measurements, we found a high inhibitory effect (ΔC_{min1} : -11.5 to -22.4 mg C. g⁻¹. SOC) of DWC
232 relative to MWET on heterotrophic respiration, whereas when measuring evolved CO₂ discontinuously,
233 i.e., only in the rewetting phase, the inhibitory effect of DWC relative to MWET was less important
234 (ΔC_{min2} : -1.26 to -5.82 mg C. g⁻¹. SOC). These results suggest a possible overestimation of the effect
235 of dry-wet cycles on SOC mineralization if the measurements are only carried out in the rewetting phase.
236 Indeed, during the drying phase, a substantial amount of carbon is mineralized, but this amount is not
237 accounted for in the global evaluation.

238

239 We did not measure any net effect of dry wet cycles on net CO₂ mineralization for cultivated
240 Luvisols with contrasted SOC contents (Table 1). Several studies have reported that a longer drying
241 phase resulted in a larger CO₂ flush after rewetting (Birch, 1960, Meisner et al., 2013), likely because
242 longer dry periods lead to more accumulation of carbon substrates available for respiration after
243 rewetting (Chowdhury et al., 2011). It is hence possible that in the present study, the drying duration
244 and intensity was not sufficient to cause a large accumulation of the substrate. However, the duration
245 and intensity of drying used in this study is close to the scenarios used in several other studies. Some
246 studies dried their soils more than we did here (e.g., Beare et al., 2009, Butterly et al., 2009, Degens and
247 Sparling, 1995, Kaisermann et al., 2013, 2015), while some did not (e.g., Fierer and Schimel, 2002,
248 Chow et al., 2006).

249

250 Based on these results, we strongly recommend to measure continuously the soil respiration
251 during dry-wet experiments and to compare the CO₂ emitted in dry-wet cycles with a control that has a
252 water content equivalent to the average water content in dry-wet cycles. In addition, we question the
253 importance of the effect of dry-wet cycles on overall CO₂ emissions, while acknowledging that, even

254 though the carbon balance might be similar, the fate of nitrogen might be very contrasted under dry wet
255 cycles, carbon peaks being associated with nitrogen peaks, which are easily leached into the soil by rain.

256

257

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259

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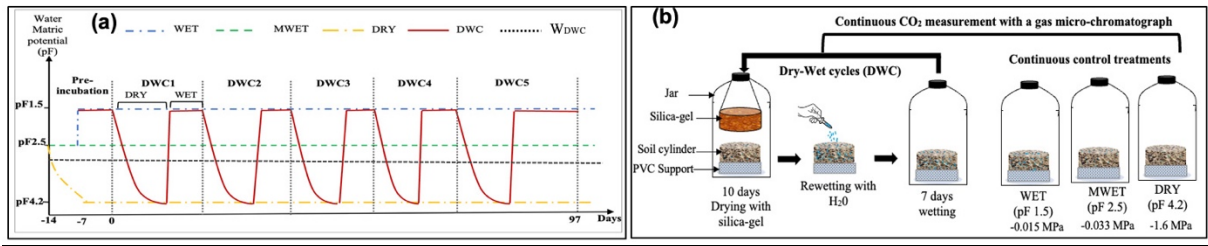
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419 **Table. 1:** Soil organic carbon contents, cumulative SOC mineralization calculated from continuous
 420 measurements (MWET, DWC) or with partial measurements only in the wet phase (pMWET and
 421 pDWC). ΔC_{min1} and ΔC_{min2} represent the delta SOC mineralized. If the value of ΔC_{min1} or ΔC_{min2}
 422 is negative, it means that DWC has an inhibitory effect, while, if the value of ΔC_{min1} or ΔC_{min2} is
 423 positive, it means that DWC has a stimulatory effect. MWET represent a scenario continuously at pF
 424 2.5 and DWC: Dry-Wet-Cycles scenario.
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LTes	TREATMENTS	SOC	SOC mineralization (mg C g ⁻¹ . SOC)					
		g.kg ⁻¹	MWET	DWC	pMWET	pDWC	$\Delta C_{min1} =$ DWC-MWET	$\Delta C_{min2} =$ pDWC-pMWET
La Cage	CON-LC	9.82 ± 0.48	44.3 ± 7.4	32.7 ± 4.7	20.76 ± 3.62	18.15 ± 4.17	-11.6 ± 8.7	-2.61 ± 5.52
	ORG	10.39 ± 0.42	55.7 ± 3.1	33.3 ± 4.3	25.98 ± 1.69	20.16 ± 1.67	-22.4 ± 5.3	-5.82 ± 2.37
	CA	13.30 ± 1.05	46.7 ± 2.6	32.8 ± 6.7	24.02 ± 1.44	18.75 ± 2.53	-13.9 ± 7.1	-5.27 ± 2.91
QualiAgro	CON-QA	10.11 ± 1.12	49.2 ± 2.2	32.2 ± 2.6	22.88 ± 2.50	21.62 ± 2.09	-17.0 ± 3.4	-1.26 ± 3.26
	MSW	13.38 ± 0.45	38.6 ± 3.3	25.5 ± 0.8	17.81 ± 1.67	15.77 ± 1.77	-13.1 ± 3.4	-2.04 ± 2.43
	FYM	14.31 ± 0.63	39.9 ± 2.4	26.5 ± 1.1	18.50 ± 1.18	16.88 ± 1.42	-13.4 ± 2.6	-1.62 ± 1.84
	BIOW	15.81 ± 1.23	35.8 ± 1.8	24.3 ± 1.9	16.60 ± 1.03	14.85 ± 1.42	-11.5 ± 2.6	-1.75 ± 1.75

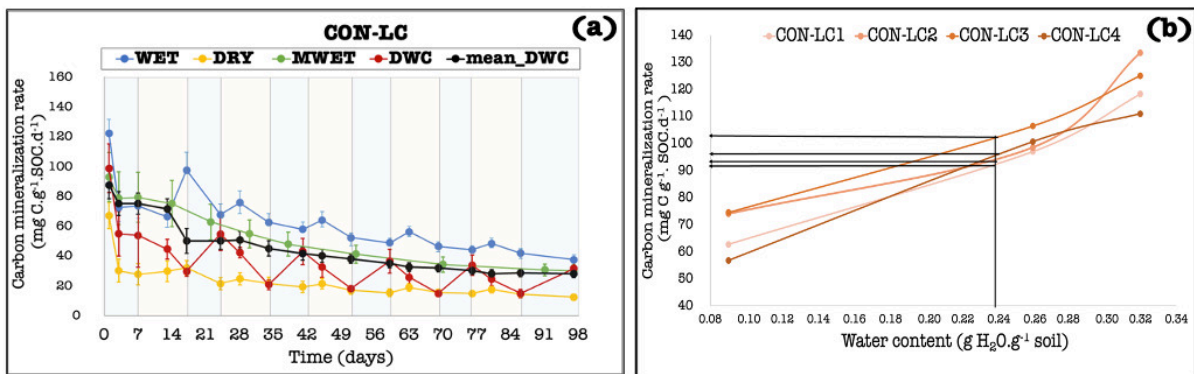
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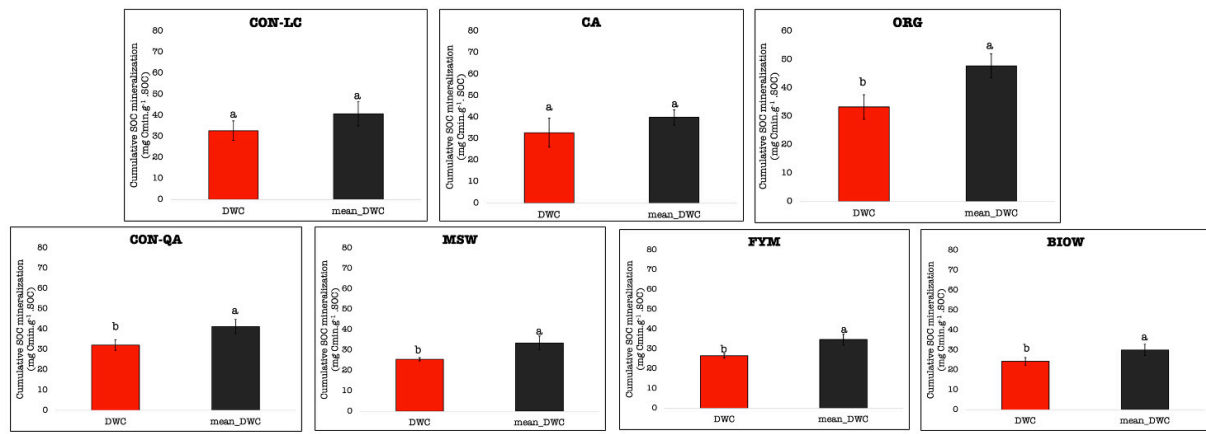
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Fig. 1: (a) A schematic diagram of the experimental design showing constant moisture scenario (WET, MWET, DRY), average water content in dry-wet cycles (W_{DWC}) and dry-wet cycles scenario (DWC), (b) diagram of incubation procedures. WET represents a continuously wet scenario at pF 1.5; MWET represents a continuously moderate wet scenario at pF 2.5 and DRY represents a continuously dry scenario at pF 4.2



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Fig. 2: (a) Carbon mineralization rates under constant soil moisture and dry-wet-cycles scenario for soil from plot under conventional agriculture at La Cage experiment (CON-LC). Error bars indicate standard deviation of 4 replicates per treatment. (b) Relationship between water content and daily mineralization rate on the CON-LC plot to reconstruct the mineralization rate corresponding to an average moisture in DWC scenario.



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Fig. 3 Cumulative SOC mineralization upon dry-wet-cycles and mean_DWC under conservation agriculture (CA), organic agriculture (ORG), conventional agriculture at La Cage (CON-LC); Conventional agriculture without organic inputs at QualiAgro (CON-QA); residual municipal solid waste compost (MSW); Farmyard Manure (FYM) and Biowaste Compost (BIOW). Error bars indicate standard deviation of 4 replicates per treatment.

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Supplementary materials

455 **Accurate evaluation of the Birch effect requires continuous CO₂ measurements and**
456 **relevant controls**

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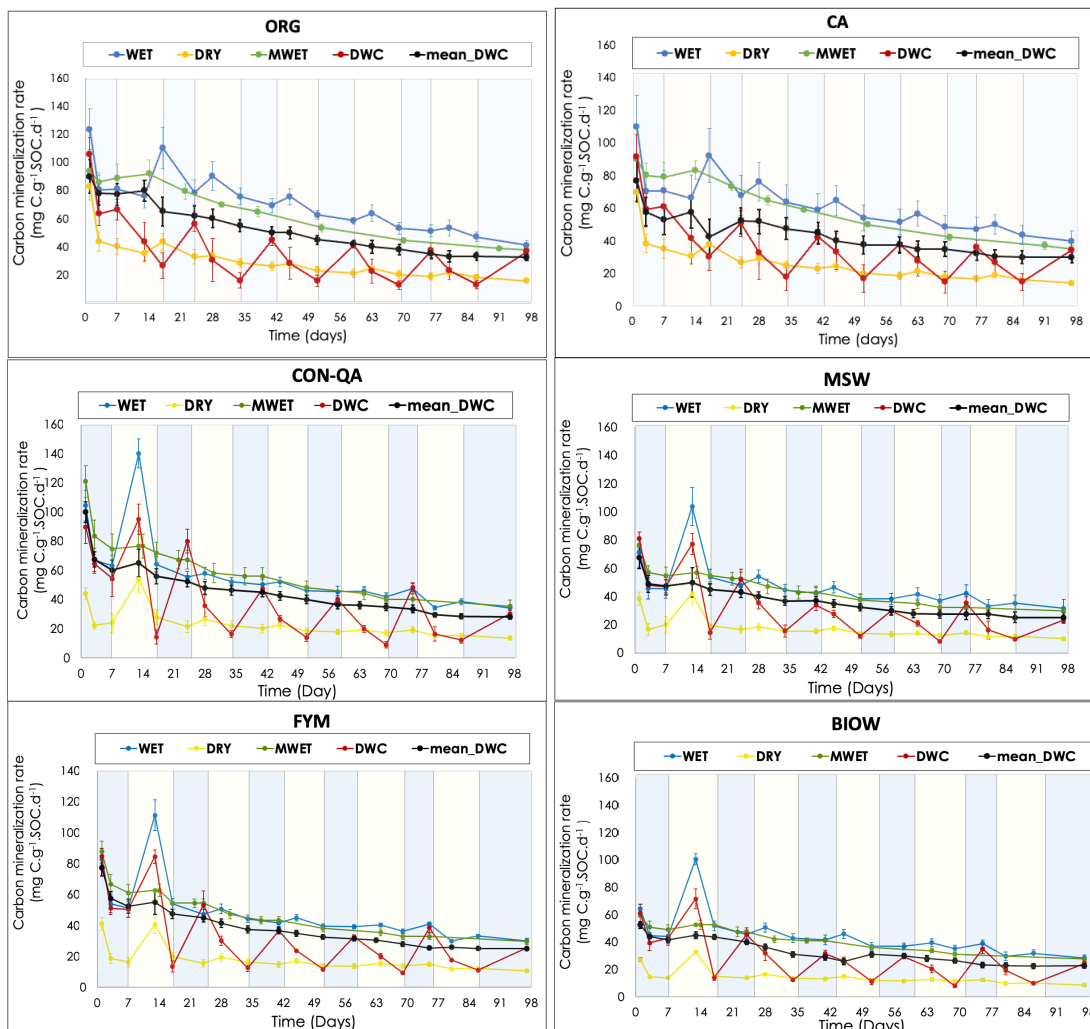
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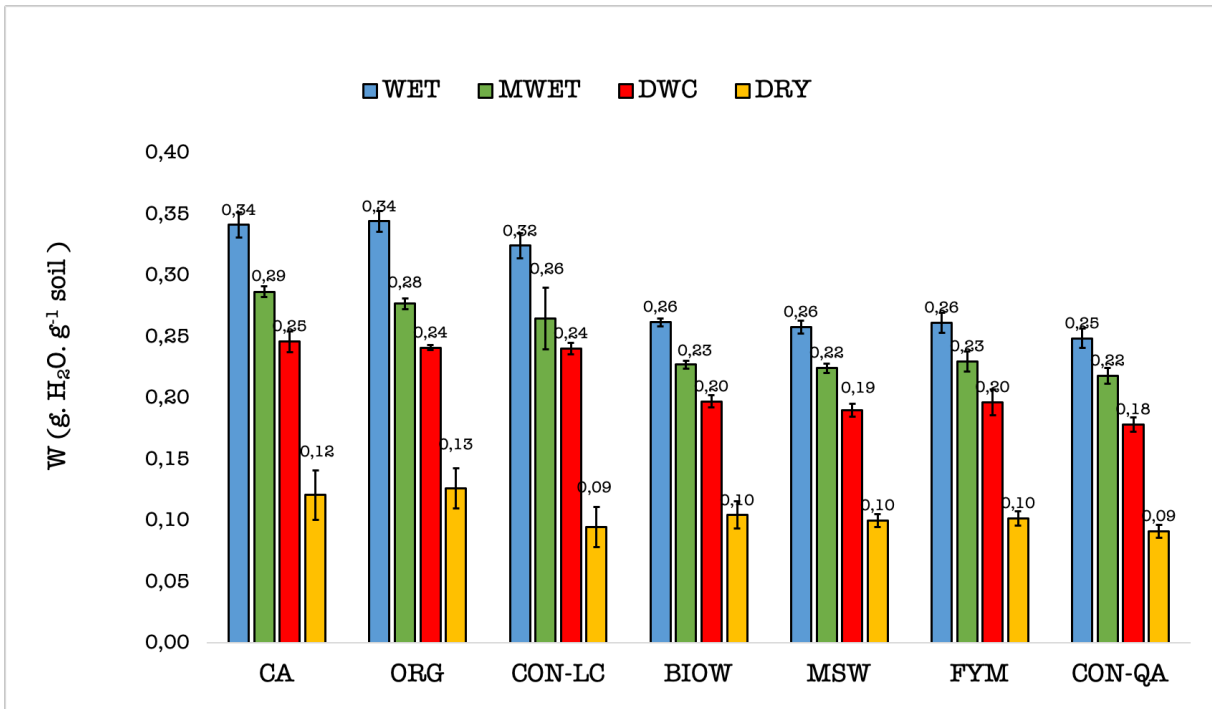
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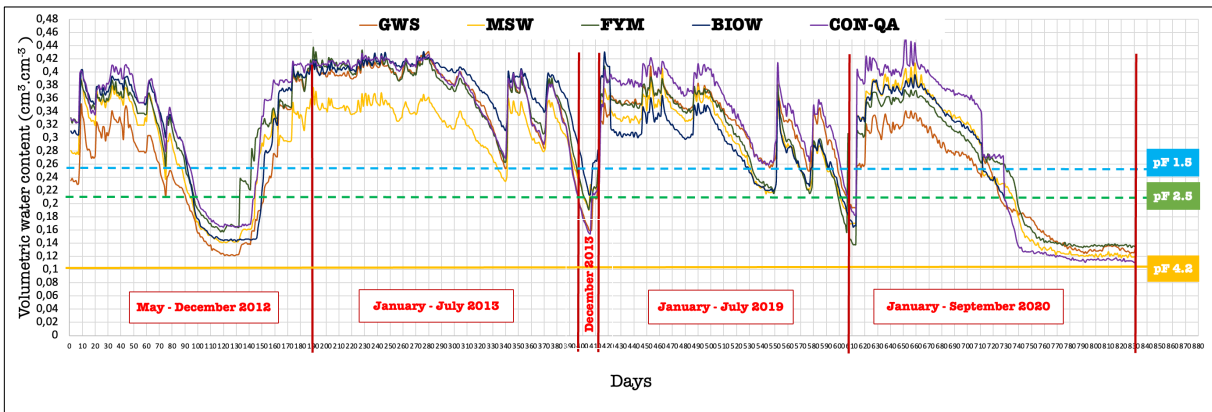
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470 **Fig. S1:** Carbon mineralization rates under constant soil moisture and dry-wet-cycles scenario for soil
471 from plots under conservation agriculture (CA), organic agriculture (ORG), CON-QA: control treatment
472 without organic inputs; MSW: residual municipal solid waste compost; FYM: Farmyard Manure and
473 BIOW: biowaste compost. Error bars indicate standard deviation of 4 replicates per treatment.



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 476 **Fig. S2:** Soil water content of the different moisture treatments tested. In the case of the DWC treatment
 477 it corresponds to an average soil moisture during drying and rewetting phases (W_{DWC}). Error bars
 478 indicate standard deviation of 4 replicates per treatment.

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 481 **Fig. S3:** Continuous measurement of volumetric water content at a depth of 20 cm in a Luvisol at
 482 QualiAgro. CON-QA: control treatment without organic inputs, BIOW: biowaste compost,
 483 MSW: municipal solid waste compost, GWS: green waste and sewage sludge compost and
 484 FYM: farmyard manure amended soils.

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