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30 Composting is a cost-effective means of recycling waste organic matter in agriculture
31 and can improve soil C storage, as has been shown in long term field experiments (Peltre et
32 al., 2012). Composts are produced through the stabilization of organic wastes progressively
33 processed by microorganisms under controlled aerobic conditions (de Bertoldi et al., 1987).
34 The degree of maturation of the compost, depending on the initial feedstock and process
35 parameters, directly influences its subsequent decomposition, once applied to soils (Bernal et
36 al. 1998; Cambardella et al., 2003). The influence of compost addition on soil properties and
37 plant productivity is well documented. However, the effects of compost on SOM
38 mineralisation are still poorly studied. It is known that fresh OM inputs can stimulate native
39 SOM degradation, a phenomenon called priming effect (PE) (Löhnis 1926; Fontaine et al.
40 2003). In a recent study, it has been shown that SOC stocks dynamics between agricultural
41 soils receiving fresh or composted straw over 52 years were similar, suggesting no long-term
42 impact of priming effect (Cardinael et al., 2015). The reason for the lack of difference are not
43 well understood however. The objective of this work was to evaluate the impact of
44 composting on the chemical composition of plant residues, their mineralisation in soil and any
45 related SOM priming effect. We hypothesized that composting would reduce the labile
46 fraction of plant material and consequently would reduce both their decomposition by soil
47 microorganisms any potential priming effects. We incubated composted and non-composted
48 ^{13}C -labelled plant residues in an arable soil for 3 years and determined the ^{13}C -labelling in the
49 CO_2 evolved, the dissolved organic carbon (DOC) and the soil microbial biomass.

50 The mixture of plant residues was composed of 23 g DW of ^{13}C -labelled wheat straw
51 ($\delta^{13}\text{C}=1749\text{‰}$), 31 g DW rapeseed leaves ($\delta^{13}\text{C}=1459\text{‰}$), 40 g DW corn stalks and leaves
52 ($\delta^{13}\text{C}=1639\text{‰}$), mixed with 403 g DW of non-labelled (-26‰) grass clippings. All residues
53 were almost dried (5% humidity) except for grass clippings (69% humidity). Ten boxes (2L)
54 containing a subsample (40g) of the mixture were placed in 170 L-composting pilot devices

55 during 90 days with forced aeration (Doublet et al., 2011). Before analyses and incubation in
56 the soil, all residues were ground to 0.2mm. The C content and ^{13}C signature were measured
57 by EA-IRMS (NA-1500, Carlo-Erba). The chemical composition and the uniformity of the
58 labelling at the molecular level was checked by analysing the lignin units by the CuO
59 oxydation method (Dignac et al., 2005), the non-cellulosic sugars by the acetate alditol
60 method (Rumpel and Dignac, 2006) and the lipid extract using BF_3 -methanol method (Lerch
61 et al., 2007) by means of GC-c-IRMS. The agricultural soil (0-28 cm plough horizon) used for
62 the incubation is located at Feucherolles, France (latitude 48.8°, longitude 1.96°). It is a silt
63 loam soil (Soil Taxonomy: Typic Hapludalf; FAO system: Albic Luvisol) with 7% sand, 76%
64 silt, 17% clay, 8.9 g kg⁻¹ of organic C, 1.1 g kg⁻¹ of N and a pH of 6.9. The soil bulk ^{13}C
65 signature was -24.8‰. After being collected and sieved moist to < 5 mm, soil samples (125 g
66 dry weight equivalent) were preincubated for 3 weeks at 20 °C and 60% of the water holding
67 capacity (WHC=0.24 mL g⁻¹ soil) in serum bottles (565 mL). Soil samples were then
68 amended either with composted or non-composted plant residues, corresponding to a C
69 addition of 11.5% of the soil organic C. Control samples did not receive any amendment.
70 Three experimental replicates were used. All samples were adjusted to 80% of the WHC,
71 flushed with CO₂ free air (19% O₂, 81% N₂) and incubated at 20 °C in the dark for 36 months.

72 Soil respiration, dissolved organic carbon (DOC) and microbial-C (MB) were monitored
73 throughout the incubation as described by Lerch et al. (2009). Briefly, the concentration and
74 isotopic signature ($\delta^{13}\text{C}$, ‰) of the CO₂ were measured at each sampling date. Then, samples
75 that were not used for destructive DOC and MB analyses, were flushed with CO₂ free air,
76 sealed again and placed back in the incubation chamber until the subsequent gas
77 measurement. The amounts of C and ^{13}C in the MB were measured on 20 g subsamples by
78 fumigation-extraction (FE) using 0.03 M K₂SO₄ as an extractant (Gaillard et al., 1999). A
79 correction factor (K_{EC}) of 0.45 was used to estimate microbial C (Vance et al., 1987). The

80 non-fumigated soil was also used to assess the DOC content. All extracts were freeze-dried
81 and their elemental and isotopic contents measured with an EA-IRMS. The relative amount of
82 ^{13}C in each fraction was obtained using a mass balance equation (see supplementary
83 information). Three analytical replicates were performed for all experimental replicates. All
84 statistical analyses (ANOVA and non-linear regression) were performed using R software
85 (version 2.12.0 R Development Core Team, 2008) and graphical representations with
86 SigmaPlot 14.0 (Systat Software, Inc.).

87 Mass loss during composting was 60% dry weight, 64% for C, and 43% for nitrogen
88 (N). The C content was $35\pm 1\%$ and $39\pm 1\%$, the C/N ratio 15.0 ± 0.4 and 9.3 ± 0.2 and the ^{13}C
89 signature $271\pm 10\text{‰}$ and $263\pm 13\text{‰}$ for the mixture of composted and non-composted plant
90 residues, respectively. The mean of the molecular ^{13}C signature (Figure S1) was similar to
91 that of the bulk ($253\pm 47\text{‰}$ and $274\pm 53\text{‰}$ for composted and non-composted plant residues,
92 respectively). Composting increased by 69% the lignin contribution to total remaining C (Fig.
93 1A) and decreased by 58% the ratio of cinnamic to syringic units. Conversely, the relative
94 amount of non-cellulosic sugars decreased by 53% after composting (Fig. 1B) with an
95 increase of C6 to C5 ratio. The lipid concentration decreased by 55% with a preferential
96 degradation of n-alcohols and n-alkanes. Comparatively, steroids and terpenes were preserved
97 and n-acids increased significantly. As expected, total CO_2 evolved was much higher in soil
98 amended with non-composted than composted plant material and control samples (Fig. 2A).
99 After 3 years of incubation, the mineralisation reached $36\pm 4\%$ and $79\pm 8\%$ of the initial C of
100 the composted and non-composted residues, respectively (Fig. 2B). The mineralisation curves
101 were fitted ($r^2 = 0.99$, $P < 0.001$) with a first order kinetic equation with 2 compartments: $y =$
102 $a(1-e^{-\alpha t}) + b(1-e^{-\beta t})$, where a and b are the mineralisation potentials and α and β the first order
103 rate constants, respectively for the labile and non-labile C pools (Lerch et al., 2011). The
104 parameters values were a = 9% and 29%, b = 91% and 71%, $\alpha = 0.03$ and 0.05 day^{-1} and $\beta =$

105 0.5×10^{-3} and $1.8 \times 10^{-3} \text{ day}^{-1}$, respectively for composted and non-composted materials. These
106 values indicate a clear relationship among the chemical composition, the dynamics of DOC
107 and MB as well as the mineralisation kinetics. Composting reduced in particular the relative
108 concentration of energetic compounds (e.g. sugars), the DOC and the amount of C
109 incorporated into the microbial biomass. Kinetics parameters also suggest that composting
110 increased significantly the residence time of added organic matter. Up until 21 days, the
111 amounts of DOC were significantly higher for samples amended with both fresh and
112 composted plant residues compared to control samples and beyond 21 days remained around
113 $45 \mu\text{gC g}^{-1} \text{ soil}$ (Fig. 3A). Composting affected the amount of DOC and ^{13}C -DOC only on the
114 first day of incubation, with a maximum of $4 \pm 1\%$ and $8 \pm 1\%$ of the initial ^{13}C amount of
115 composted and non-composted plant materials, respectively (Fig. 3B). The microbial C was
116 significantly higher for amended than non-amended samples at day 3 (Fig. 3C) but no
117 difference were observed between non-composted and composted samples. Initially, a similar
118 amount of ^{13}C -biomass was found in both fresh and composted plant residues (1 to 2% of the
119 initial ^{13}C amount). Subsequently, during the first 30 days of incubation, the amount of ^{13}C
120 incorporated into the microbial biomass was significantly higher for non-composted residues
121 (Fig. 3D). The maximum values were observed after 3 days of incubation with $3 \pm 1\%$ and
122 $6 \pm 1\%$ of the initial amount of ^{13}C , respectively for composted and non-composted plant
123 residues. We did not observed a PE with composted residues while non-composted ones
124 increased SOM mineralisation by $21 \pm 7\%$ after 3 years of incubation, compared to the control
125 (Fig. 2C).

126 It is known that composting affects the chemical composition of fresh organic material
127 (e.g. Almendros et al., 1991; González-Vila et al., 1999; Dignac et al., 2005). Here we
128 observed a preferential decrease of carbohydrates and lipids compared to the lignin
129 monomers, which is in line with previous studies made on plant composting (Almendros et

130 al., 2000). The increase of the C6 to C5 ratio upon composting (from 0.63 to 1.44) indicates
131 that some plant-derived sugars were degraded while new sugars were synthesized by microbes
132 (Goyal et al., 2005; Kato and Miura, 2008). This is consistent with the relative increase of
133 fatty acids originated from the microbial biomass in the lipid extract such as mono-
134 unsaturated, cyclopropyl, iso- and anteiso fatty acids (data not shown). . The preferential
135 degradation of n-alcohols and n-alkanes and the relative preservation of steroids and terpenes
136 during composting have been reported by Spaccini and Piccolo (2007). The decreased in the
137 ratio of cinnamic to syringic units is in agreement with the results from González-Vila et al.
138 (2009) which indicates that the lignocellulosic material was partly transformed during the
139 thermophilic stage. As expected, the chemical changes of plant residues during composting
140 affected significantly their mineralisation in soil. We estimated that the size of the labile C
141 pool was decreased by 70%, which is consistent with the decrease of lipids and sugars
142 proportion after composting. The turnover of labile and non-labile C pools increased,
143 probably due to the preservation of more recalcitrant compounds in both pools, as observed in
144 the chemical analyses. The absence of PE when adding compost to the soil could be explained
145 by the fact that the more labile organic compounds that served as potential C and energy
146 source for microbial growth had previously been used during composting (Said-Pullicino et
147 al., 2007). Sikora and Yakovchenko (1996) also observed that compost addition did not
148 stimulate the mineralisation of two-year old SOM previously labelled with ^{14}C -straw. In terms
149 of C budget, the total loss of CO_2 (including the composting process and the SOM priming)
150 was comparable for both treatments after 600 days of incubation (Fig. 2D). It would have
151 taken about 300 more days to reach this equivalence if SOM priming effect was not included,
152 which shows the importance of taking this mechanism into account when comparing soil
153 amendments C budget. These results could be useful to better incorporate PE mechanisms
154 into global carbon models (Guenet et al., 2018). From a practical point of view, this study

155 demonstrates that composting plant residues increases soil C inputs but does not increase
156 SOM decomposition rate as commonly observed when adding fresh residues.

157

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163

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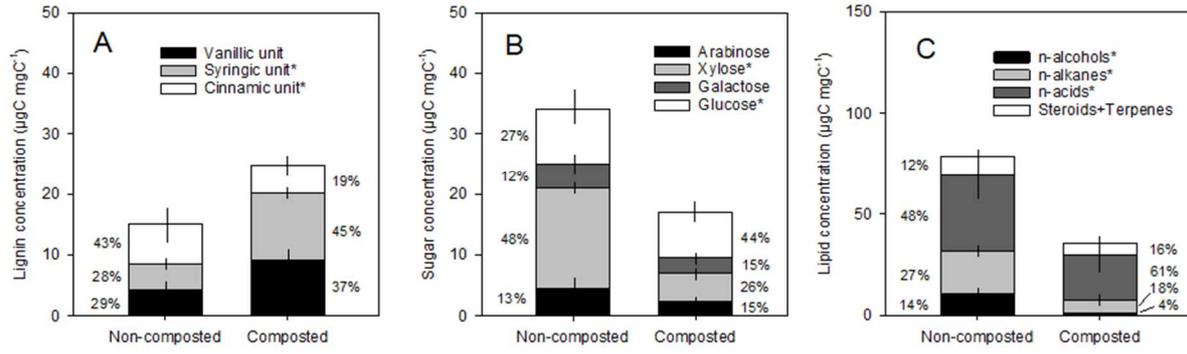
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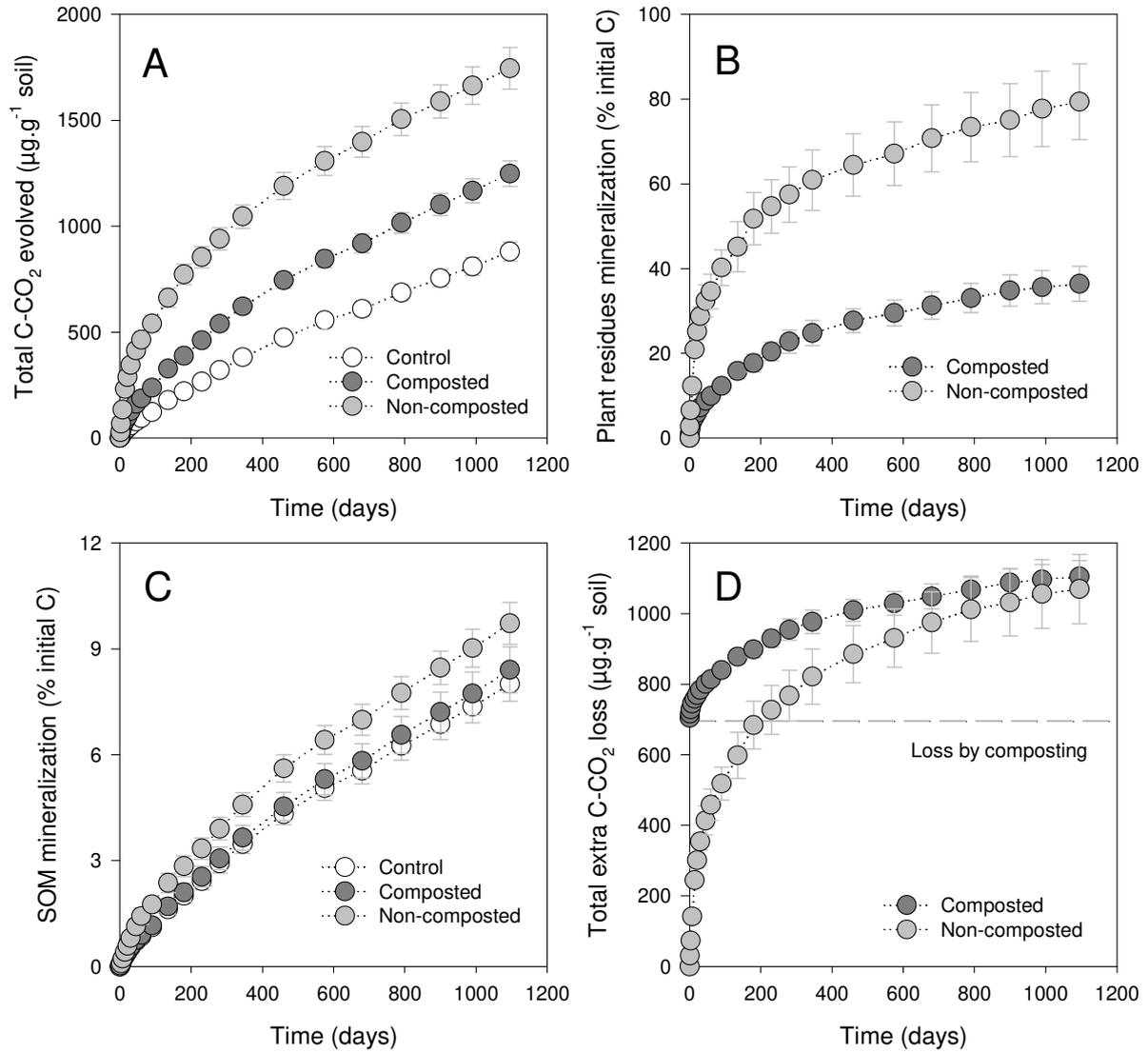
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1
 2 **Figure 1:** Lignin (A), non-cellulosic sugar (B) and lipid concentration (C) in the non-composted and composted
 3 plant residues. Lignin content is the sum of vanillic, syringic and cinnamic units. Non-cellulosic sugar content is
 4 the sum of arabinose, xylose, galactose, glucose (other minor molecules represented less than 10%). Lipid content
 5 is the sum of n-alcohols, n-alkanes, n-acids, steroids and terpenes. Data are the mean of three replicates. The
 6 proportion of each molecules (%) in a given fraction is represented beside the bars. Significant differences
 7 ($P < 0.005$) in the mass proportion of a molecule upon composting are indicated by a star (*) in the legend.

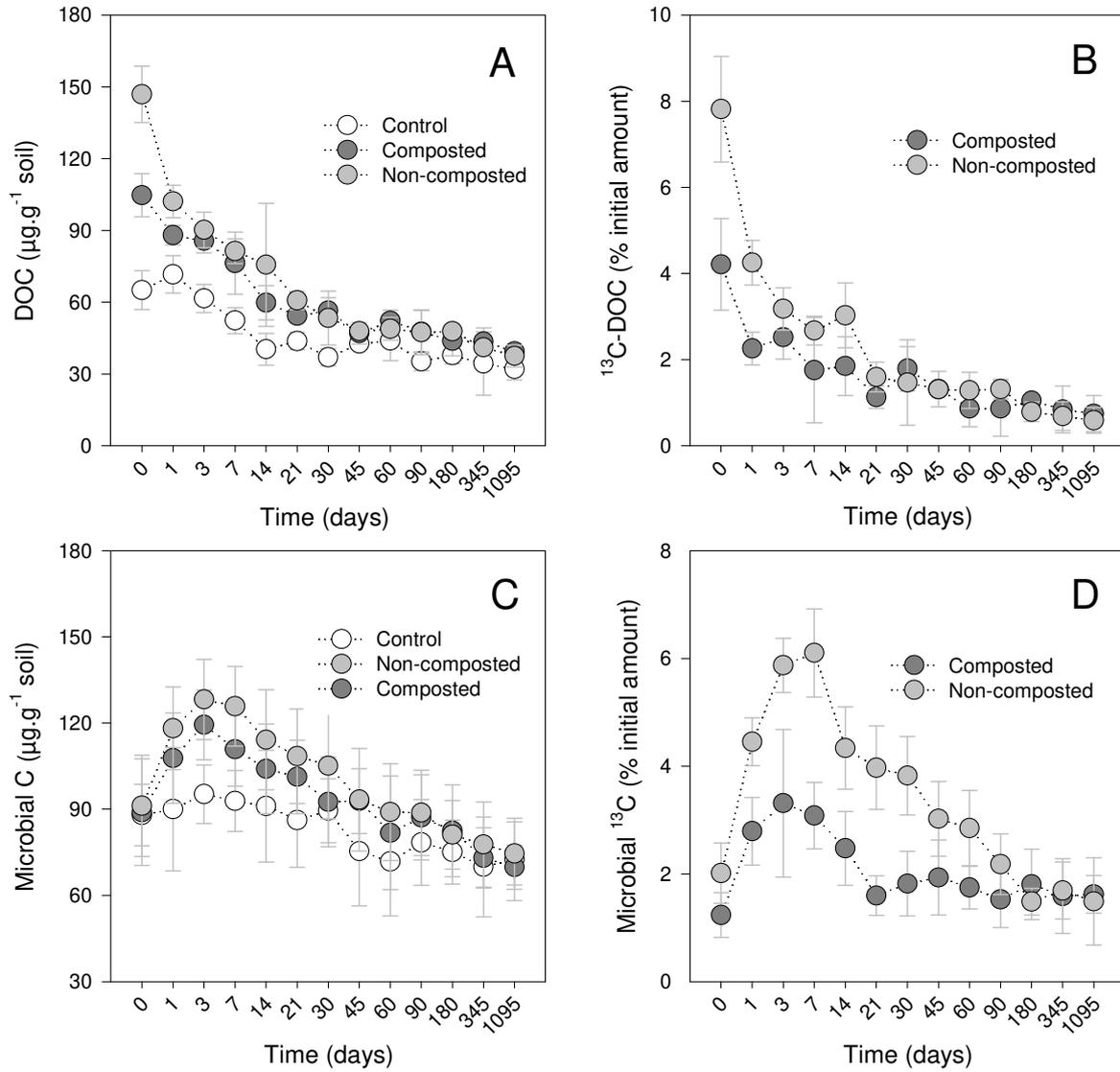
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10 **Figure 2:** Total CO₂ emitted in µC g⁻¹ soil (A), plant residues mineralization (relative to the initial amount of C
 11 from composted or non-composted material) (B), SOM mineralization in µC g⁻¹ soil (C) and CO₂ evolved relative
 12 to the initial amount of carbon prior composting with CO₂ lost during composting and taken into account priming
 13 effect (D). Standard deviations correspond to three replicates.

14



15

16 **Figure 3:** Dissolved organic carbon (DOC) in $\mu\text{C g}^{-1}$ soil (A), ^{13}C -labelled DOC relative to the initial ^{13}C amount
 17 of composted or non-composted plant residues (B), microbial C in $\mu\text{C g}^{-1}$ soil (C) and microbial- ^{13}C relative to the
 18 initial ^{13}C amount of composted or non-composted plant residues (D). Standard deviations correspond to three
 19 replicates. The scale of time is nonlinear.