Short communication

Direct effects of litter decomposition on soil dissolved organic carbon and nitrogen in a tropical rainforest

Wen-Jun Zhou a, b, c, Li-Qing Sha a, b, Douglas A. Schaefer a, b, Yi-Ping Zhang a, b, *, Qing-Hai Song a, b, c, Zheng-Hong Tan a, b, c, Yun Deng a, b, Xiao-Bao Deng a, b, Hui-Lin Guan d

A R T I C L E   I N F O

Article history:
Received 15 August 2014
Received in revised form 29 October 2014
Accepted 18 November 2014
Available online 9 December 2014

Keywords:
Dissolved organic carbon
Dissolved nitrogen
Litter decomposition
Limiting factor
Tropical rainforest

A B S T R A C T

To clarify how litter decomposition processes affect soil dissolved organic carbon (DOC) and soil dissolved nitrogen (DN) dynamics, we conducted a field experiment on leaf litter and collected DOC and DN from the underlying soil in a tropical rainforest in Xishuangbanna, southwest China. Principal components analysis (PCA) showed the first PCA axis (corresponding to degraded litter quantity and quality) explained 61.3% and 71.2% of variation in DOC and DN concentrations, respectively. Stepwise linear regression analysis indicated that litter carbon mass controlled DOC and hemicellulose mass controlled DN concentrations. Litter decomposition was the predominant factor controlling surface-soil DOC and DN dynamics in this tropical rainforest.

© 2014 Elsevier Ltd. All rights reserved.
and finally lignin (Kalbitz et al., 2006, 2007). All these fractions lead to the release of C and N from litter by decomposition and allow them to enter soil. Thus the large variances in DOC and DN explained by PC1 indicate that degraded litter quality and quantity influence soil DOC and DN dynamics. This result predicts that decomposing litter mass influences forest surface soil DOC and DN dynamics in tropical forests, as in other forests (Li et al., 2003; Don and Kalbitz, 2005; Park and Matzner, 2006; Uselmann et al., 2007). To clarify which litter fraction is the most limiting factor on concentrations of DOC and DN in surface soils, a stepwise linear regression between DOC and DN concentrations and all 7 PC1 parameters was performed, and showed the following:

$$\text{DOC concentration} = 10.727 + 21.527 \text{ litter carbon mass};$$

$$r^2 = 0.720, \ p < 0.001$$

$$\text{DN concentration} = 4.269 + 18.92 \text{ hemicellulose mass};$$

$$r^2 = 0.800, \ p < 0.001$$

These results show that the strongest limiting factor for DOC was litter carbon mass. Although different litter fractions varied during decomposition (Supplementary Fig. S2), the litter carbon mass is sum of all carbon fractions. So, litter carbon mass controlled surface-soil DOC concentration dynamics. In contrast, the limiting factor for soil DN was hemicellulose mass, composed of sugar polymers. A significant correlation between sugars and microbial mass has been observed, as nitrogen biogeochemical dynamics are controlled by microbiota (Ghehi et al., 2013). We conclude from our study and the results of Ghehi et al. (2013) that DN dynamics is associated with variations in monosaccharide components.

Soil temperature, moisture and rainfall were positively correlated to litter decomposition rates (Fig. 2, Supplementary Table S1), thus influence litter remaining mass and then affect surface soil DOC and DN dynamics according to PC2 and our stepwise linear regression results (Fig. 2). In the short term, relationships between DOC and SOC concentrations, and between DN and soil nitrogen concentrations, were not significant at our study site, inconsistent with the conclusion that DOC and DN varied with soil C and N in the long term (Saviozzi et al., 1994; Delprat et al., 1997; Gregorich et al., 2000).

Therefore, this study showed that in tropical forest, factors most directly affecting surface-soil DOC and DN are litter carbon mass and hemicellulose mass respectively during litter decomposition. Considering that global change may affect litter input and decomposition rates, to clarify the role of DOC and DN in C and N cycles, more attention should be paid to the mechanisms controlling biogeochemical cycles of DOC and DN in future studies.

### Table 1

Correlations between concentrations of DOC and DN and all other measured parameters in the tropical rainforest of Xishuangbanna, Southwest China. This table only shows significant correlations between DOC and DN and litter, soil and environment parameters (Pearson correlation test). LRM: litter remaining mass; LC: litter carbon content; CEC: litter cellulose content; T10: soil temperature at 10 cm depth; LCM: litter carbon mass; LNM: litter nitrogen mass; NDFM: litter neutral detergent fibre mass; ADFM: litter acid detergent fibre mass.

<table>
<thead>
<tr>
<th></th>
<th>LRM</th>
<th>LC</th>
<th>CEC</th>
<th>T10</th>
<th>LCM</th>
<th>LNM</th>
<th>NDFM</th>
<th>ADFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOC</td>
<td>0.6229*</td>
<td></td>
<td>0.5804*</td>
<td></td>
<td>0.5884*</td>
<td></td>
<td>0.6335*</td>
<td>0.7769**</td>
</tr>
<tr>
<td>DN</td>
<td>0.6683**</td>
<td>0.5656*</td>
<td></td>
<td>0.6679*</td>
<td>0.7485*</td>
<td>0.6351*</td>
<td>0.7460**</td>
<td></td>
</tr>
</tbody>
</table>

*Correlation is significant at the 0.01 level (2-tailed). **Correlation is significant at the 0.05 level (2-tailed).
Varimax with Kaiser normalization. LDR: litter decomposition rate; LRM: litter remain mass; LC, litter carbon content; LN: litter nitrogen content; ADF.C: litter acid detergent fibre content; NDF.C: litter neutral detergent fibre content; HE.C: litter Hemicellulose content; CE.C: litter Cellulose content; LC.M: litter carbon mass; LN.M: litter nitrogen mass; NDF.M: litter neutral detergent fibre mass; ADF.M: litter acid detergent fibre mass; HE.M: litter Hemicellulose mass; CE.M: Litter cellulose mass; Lin.C: litter lignin mass; TO: surface temperature; T10: soil temperature at 10 cm depth; R: rainfall; SWC: soil water content of soil sample time; SWC5, monthly soil water content; SOC: soil organic carbon content; SN: soil nitrogen content. Litter sampling and quality and quantity analysis method. Five litter bags were randomly collected each month, one from each row from February 2010, after a total of 12 months of field exposure. For each harvested litter bag, we measured the percentage of litter mass remaining (LMR), the monthly litter decomposition rate (LDR) by oven dried method. After drying and weighing, the harvested litter was ground to pass a 1-mm screen. Total concentrations of C and N were determined using an element auto analyser (Vario MAX CN, Elementar Analysensysteme GmbH, Germany).

Fig. 2. Principal component analysis of patterns in litter, soil and environmental variables during the decomposition progress under the litter bag in the tropical rainforest of Xishuangbanna, southwest China. Notes: The first two axes (shows in the circles) explain 48.00 and 19.44% of the variability, respectively. Extraction method: PCA; Rotation method: Varimax with Kaiser normalization. LDR: litter decomposition rate; LRM: litter remain mass; LC, litter carbon content; LN: litter nitrogen content; ADF.C: litter acid detergent fibre content; NDF.C: litter neutral detergent fibre content; HE.C: litter Hemicellulose content; CE.C: litter Cellulose content; LC.M: litter carbon mass; LN.M: litter nitrogen mass; NDF.M: litter neutral detergent fibre mass; ADF.M: litter acid detergent fibre mass; HE.M: litter Hemicellulose mass; CE.M: Litter cellulose mass; Lin.M: litter lignin mass; TO: surface temperature; T10: soil temperature at 10 cm depth; R: rainfall; SWC: soil water content of soil sample time; SWC5, monthly soil water content; SOC: soil organic carbon content; SN: soil nitrogen content. Litter sampling and quality and quantity analysis method. Five litter bags were randomly collected each month, one from each row from February 2010, after a total of 12 months of field exposure. For each harvested litter bag, we measured the percentage of litter mass remaining (LMR), the monthly litter decomposition rate (LDR) by oven dried method. After drying and weighing, the harvested litter was ground to pass a 1-mm screen. Total concentrations of C and N were determined using an element auto analyser (Vario MAX CN, Elementar Analysensysteme GmbH, Germany).

Acknowledgements

We thank two anonymous reviewers, Jiao-Lin Zhang, Jan Mulder, Stephen Hättenschwiler, and Jing Zhu for comments and assistance in improving this manuscript. This work was supported by the NSFC (40801035, U1202234, 31290221, 41361075), the Key Laboratory of Tropical Forest Ecology, CAS (09KF001B04), the strategic Priority Research Program of CAS (XDA05020302, XDA05050601), and the CAS 135 project (XTBG-F01). We appreciate the staff and technicians of the Xishuangbanna Station for the Tropical Rain Forest Ecosystem, and the Biogeochemistry Laboratory of the Public Technology Service Center of XTBG, CAS, for field measurements and litter and soil analyses.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.soilbio.2014.11.019.

References


Park, J., Matzner, E., 2006. Detrital control on the release of dissolved organic nitrogen (DON) and dissolved inorganic nitrogen (DIN) from the forest floor under chronic N deposition. Environmental Pollution 143, 178–185.


