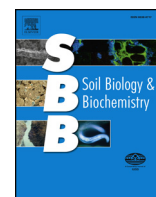


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## Contrasting effects of organic and mineral nitrogen challenge the N-Mining Hypothesis for soil organic matter priming

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## ABSTRACT

Addition of easily available organic substances to soil often increases the CO<sub>2</sub> efflux from pre-existing soil carbon (C). This phenomenon is often explained in terms of the Nitrogen (N)-Mining Hypothesis. According to this proposed – but never conclusively proven – mechanism, increased C availability induces N limitation in microbes, which then access N by degrading soil organic matter (SOM) – a priming effect. This is supported by some experiments demonstrating reduced CO<sub>2</sub> efflux after mineral N addition. However, amino acids cause priming, despite their very low C:N ratios and rapid deamination to mineral N. To explore this contradiction, we applied <sup>14</sup>C- and <sup>15</sup>N-labelled C and N sources (glucose, alanine and ammonium sulfate) to rigorously test two key predictions of the N-Mining Hypothesis: (i) an amino acid should stimulate much less priming than glucose, and (ii) priming should be similarly suppressed for an amino acid or a stoichiometrically equivalent addition of glucose plus mineral N. Both of these key predictions of the N-Mining Hypothesis failed. Efflux of CO<sub>2</sub> from native C was essentially determined by the type and amount of C added, with alanine stimulating more priming than glucose (16–50% cumulative increase relative to control, versus 0–25%, respectively). Higher C additions caused more priming than low additions. Mineral N reduced native-C-derived CO<sub>2</sub> efflux when added alone or with organic substrates, but this effect was independent of the organic C additions and did not influence C-induced priming. These results were inconsistent with the hypothesized role of N mining in priming. We conclude that the N-Mining Hypothesis, at least in its current form, is not a universal explanation for observed priming phenomena.

Instead, we observed a strong correlation between the rates of priming and the mineralization of the added substrates, especially during the first 8 days. This indicated that priming was best explained by energy-induced synthesis of SOM-degrading exoenzymes, possibly in combination with apparent priming from accelerated turnover of microbial biomass.

### 1. Introduction

The processes governing soil organic matter (SOM) mineralization are not yet fully understood, despite their considerable importance to C sequestration, greenhouse gas emissions, soil fertility and groundwater protection. Mechanistic explanations often point to interactive effects of carbon (C) and other nutrients, notably nitrogen (N). The N-Mining Hypothesis is a prominent example. According to this hypothesis, N-limited microorganisms mineralize SOM to access the N contained within (Fontaine et al., 2011; Moorhead and Sinsabaugh, 2006). This can elegantly explain why an easily available C input often increases the CO<sub>2</sub> efflux from pre-existing soil C (Kuzyakov, 2010): when supplied with an abundant source of C and energy, microorganisms

become N-limited and actively degrade organic materials that they would not degrade to acquire C alone (Garcia-Pausas and Paterson, 2011). Therefore, according to the N-Mining Hypothesis, SOM mineralization is negatively correlated to N availability, and positively correlated to C availability (Fontaine et al., 2011).

A change in SOM mineralization rate in response to relatively moderate treatment is termed a priming effect (PE) (Kuzyakov et al., 2000). Organic substances added to soil will be mineralized and therefore contribute to the total CO<sub>2</sub> efflux, but isotopic labelling (<sup>13</sup>C or <sup>14</sup>C) allows this to be distinguished from CO<sub>2</sub> derived from pre-existing soil C pools. Here we refer to these pools as “native C”, which includes the living soil microbial biomass and non-living SOM at the time of exogenous C addition. Exogenous carbon could increase or

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