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Review

Review of mechanisms and quantification of priming effects

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Abstract

Priming effects are strong short-term changes in the turnover of soil organic matter caused by comparatively moderate treatments of the soil. In the course of priming effects large amounts of C, N and other nutrients can be released or immobilized in soil in a very short time. These effects have been measured in many field and laboratory experiments; however, only a few of the studies were aimed at an extended investigation of the mechanisms of such phenomena. The aim of this overview is to reveal possible causes and processes leading to priming actions using the references on agricultural ecosystems and model experiments. Multiple mechanisms and sources of released C and N are presented and summarized in Tables for positive and negative real and apparent priming effects induced after the addition of different organic and mineral substances to the soil. Soil microbial biomass plays the key role in the processes leading to the real priming effects. The most important mechanisms for the real priming effects are the acceleration or retardation of soil organic matter turnover due to increased activity or amount of microbial biomass. Isotopic exchange, pool substitution, and different uncontrolled losses of mineralized N from the soil are responsible for the apparent N priming effects. Other multiple mechanisms (predation, competition for nutrients between roots and microorganisms, preferred uptake, inhibition, etc.) in response to addition of different substances are also discussed. These mechanisms can be distinguished from each other by the simultaneous monitoring of C and N release dynamics; its comparison with the course of microbial activity; and by the labelling of different pools with ¹⁴C or ¹³C and ¹⁵N. Quantitative methods for describing priming effects and their dynamics using ¹⁴C and ¹⁵N isotopes, as well as for non-isotopic studies are proposed. © 2000 Elsevier Science Ltd. All rights reserved.

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1. Introduction

In many studies on the transformation of substances added to soil, a side effect can be detected — an increased release of the soil-derived carbon as CO₂ or nitrogen as NH₄⁻ or as NO₃⁺ compared to the mineralization in the soil without any additions. This is a result of the interactions between the transformation of the added substances and the natural soil cycles of both elements. A few extended studies concerned with

these interactions have shown differing results strongly dependent on the experimental conditions, especially if C or N transformations were investigated and which kind of substances were added to the soil. These non-additive interactions, which cause an extra release of soil-derived C or N, were summarized under the generic term “priming effects”.

The priming effect was discovered by Löhnis (1926) by studying the decomposition of green manure of legume plants in soil. He found intensified mineralization of the humus N by the addition of fresh organic residues to soil. In the following 20 y the phenomenon was left out of consideration. It was not before the middle of the 1940s and in the 1950s that priming effects were studied again in experiments by Broadbent

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