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Basal organic phosphorus mineralization in soils under different farming systems

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Abstract

Soil organic P (P_o) mineralization plays an important role in soil P cycling. Quantitative information on the release of available inorganic P (P_i) by this process is difficult to obtain because any mineralized P_i gets rapidly sorbed. We applied a new approach to quantify basal soil P_o mineralization, based on $^{33}PO_4$ isotopic dilution during 10 days of incubation, in soils differing in microbiological activity. The soils originated from a 20 years old field experiment, including a conventional system receiving exclusively mineral fertilizers (MIN), a bio-organic (ORG) and bio-dynamic (DYN) system. Indicators of soil microbiological activity, such as size and activity of the soil microbial biomass and phosphatase activity, were highest in DYN and lowest in MIN. In order to assess P_o hydrolysis driven by phosphatase in sterile soils, a set of soil samples was γ-irradiated. Basal P_o mineralization rates in non-irradiated samples were between 1.4 and 2.5 mg P kg^{-1} day^{-1} and decreased in the order DYN > ORG ≥ MIN. This is an amount lower, approximately equivalent to, or higher than water soluble P_i of MIN, ORG and DYN soils, respectively, but in every soil was less than 10% of the amount of P isotopically exchangeable during one day. This shows that physico-chemical processes are more important than basal mineralization in releasing plant available P_i. Organic P mineralization rates were higher, and differences between soils were more pronounced in γ-irradiated than in non-irradiated soils, with mineralization rates ranging from 2.2 to 4.6 mg P kg^{-1} day^{-1}. These rates of hydrolysis, however, cannot be compared to those in non-sterile soils as they are affected by the release of cellular compounds, e.g. easily mineralizable P_o, derived from microbial cells killed by γ-irradiation.

Keywords: P mineralization; Isotopic dilution; Phosphatase activity; P availability; Farming systems

1. Introduction

Organic phosphorus (P_o) constitutes between 20 and 80% of total soil P (Dalal, 1977; Tiessen et al., 1994). Soil P_o is derived from microbes, plants or animals, and may be recycled into the soil microbial biomass or stabilized in the soil matrix. The mechanisms of stabilization can be through the carbon moiety or through interactions of the PO_4 group with organic and/or mineral compounds (Ognalaga et al., 1994). To become plant available, P_o must be mineralized (Frossard et al., 1995). Similarly, the availability of P held in the soil microbial biomass, or in plant debris, depends upon the disruption of protecting cell structures. Adapted from the concept of soil N mineralization (Mary and Recous, 1994), net P_o mineralization consists of different processes: basal mineralization, flush effects, re-mineralization (these three fluxes constitute gross mineralization) and biological immobilization. Basal P mineralization can be defined as the mineralization of soil organic matter (SOM) in a soil that has not received fresh organic matter inputs recently, i.e. at basal soil respiration with constant respiration rates. It presents the basal potential of a soil to deliver inorganic P (P_i) from soil P_o to the soil solution (Oehl et al., 2001b). Flush effects are caused by sequences of drying–wetting or freezing–thawing (Mary and Recous, 1994) and are partly due to microbial death and subsequent decomposition of microbial cells. They probably also result from the physical disturbance of the soil decreasing physical protection of SOM. Re-mineralization is the microbial P release after the main

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