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Functional response of soil microbial communities to tillage, cover crops and nitrogen fertilization

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ABSTRACT

Agricultural practices such as tillage, cover crops, and nitrogen (N) fertilization affect physico-chemical and biological soil parameters. However, these factors were often studied separately and their combined effects remain unclear, especially with respect to soil microbial functional diversity and carbon (C) and N content. Thereafter, we aim to assess the links between cropping systems and functional response of microbial communities by using a large range of soil chemical and biological measurements. A 5-yr field experiment was conducted in Northern France using a combination of three factors: i) no-till (NT) *vs.* conventional tillage (CT); ii) with or without winter cover crops (bare fallow; cover crops with a low prevalence of legumes; cover crop with a high prevalence of legumes); and iii) with or without N fertilization.

C and N inputs from cover crops and crop residues, C and N content, enzyme activities, and microbial functional diversity in the topsoil (0–10 cm) were measured over an industrial crop rotation: wheat, pea, corn, wheat, flax. No-till combined with any of the cover crops was characterized by increased total soil organic C and N contents by more than 20% between 2010 and 2015. Dehydrogenase and urease activities were significantly greatest under NT, irrespective of the presence of cover crops. Cover crops without N fertilization under no-till led to higher microbial functional activity (faster carbohydrate and phenolic compound degradation) and diversity. Bare fallow had lower soil microbial functional diversity and C and N contents compared with soil under NT and cover crops. On the other hand, NT associated with cover crops allowed to maintain the soil in both C and N, and to promote microbial activities without N fertilization. In conclusion, winter cover crops and/or NT are sustainable agricultural practices resulting in a greater soil quality index. These results demonstrate that NT and use of standard cover crops or cover crops with legumes for 5 years under a low biomass return in industrial crop production have a positive effect on: i) upper soil C content and microbial enzymes, irrespective of N fertilization regime; ii) soil microbial functional diversity in the absence of N fertilization.

1. Introduction

Alternative farming practices such as direct seeding mulch-based cropping systems are often employed to reduce the depressive effects of intensive farming on soil fertility. These practices are known to improve ecological relations between plants, soil, and microorganisms (Chaussod 1996; Alvarez et al., 2002; Marinari et al., 2006), while conventional tillage (CT) depletes physico-chemical properties of soil (Chen et al., 2009; Mangalassery et al., 2015). Nevertheless, the response of soil carbon (C) and nitrogen (N) as well as microorganisms to different farm management patterns are still poorly understood, being dependent on many factors such as pedoclimate and crop rotation. Furthermore, the combined effects of different agricultural practices on the chemical and biological properties of soil received little attention so far (Acosta-Martinez et al., 2011).

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