THE IMPORTANCE OF FUNGAL/BACTERIAL RATIO IN GRASSLANDS

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Abstract

The microbiota has a critical role in regulating soil ecosystem-level processes, such as nutrient cycling and organic matter decomposition. Scientific community has a little knowledge about the composition and diversity of microbial communities and how these affect the fertility of the soil and productivity of the grassland. An indicator which gives important information about grasslands management strategies is the fungal/bacterial ratio. This article tries to gather the results of the studies which assessed the fungal/bacterial ratio. In order to make this research paper Google Scholar scientific database was used to search for scientific literature such as academic journals, conference paper, books, dissertations, theses, abstracts and other academic literature. Database search was done using a set of keywords: "grassland", microbial biomass", "microbiota", "fungal/bacteria ratio".

Keywords: grassland, fungi, bacteria, microbial biomass, soil, management.

INTRODUCTION

There is a great interest in the development of agricultural land management strategies aimed at increasing dependence on ecosystem self-regulation, rather than on artificial inputs such as fertilizers and pesticides (Altieri, 1991). An important requirement of these systems is the need to increase dependence on natural biological processes of the soil, such as organic matter decomposition and nutrient mineralization, for the supply of plant nutrients available for growing crops. To achieve this goal, it is obvious that management regimes that encourage a soil community that resembles the natural ecosystems most likely will require fewer inputs because they rely more on self-regulation of ecosystems (Yeates *et al.*, 1997).

Soil microbes play important roles in decomposition of organic matter, nutrient cycling, and plant nutrient availability in all ecosystems (Paul and Clark, 1989). However there is little knowledge about the composition and diversity of microbial communities and how the microbiota can affect the fertility of the soil and productivity (Grayston *et al.*, 2001). Most of the knowledge about microbial communities is based on the estimated 1–10% of the total community (Torsvik *et al.*, 1998). The microbial communities respond to soil management, organic matter, and the abiotic environment, and are influenced by plant litter and rhizosphere effects (Calderón *et al.*, 2000; Chen and Stark, 2000). Some landscape-level studies have shown relationships between soil microbial community composition, and biotic and abiotic environmental conditions (Myers *et al.*, 2001). The microbial biomass is higher during wet environmental periods than dry periods (Sandor *et al.*, 2011). The main decomposition pathways in soil are bacterial-based or fungal-based, both support their own chain of soil fauna (Wardle and Lavelle, 1997). Therefore, the biomass of fungi compared to bacteria can be considered as an indicator for the activity of two pathways of the soil food web, formed by fungivores or bacterivores and their predators, respectively. Generally, fungal biomass is found to be greater than bacterial biomass in agricultural soils (Zelles *et al.*, 1995). Fungi have hyphae that allow them to move, colonize and degrade surface litters with which soil bacteria can not contact (Holland and Coleman, 1987). Chemical composition of fungal biomass is more complex than bacterial biomass (Guggenberger *et al.*, 1999). For example, the two components of fungal cell walls are polymers of melanin and chitin, while the main component of bacterial membranes are phospholipids. Polymers are much more resistant to degradation, while phospholipids are rich in energy substrates and readily decomposed by a wide range of soil microorganisms. Bacteria tend to have lower C assimilation efficiencies than fungi, and thus store less of the C that they metabolize (Adu and Oades, 1978). In some cases, C-leaf fungal storage was 26 times higher than the corresponding bacterial deposition of C (Suberkropp and Weyers, 1996). Thus, storage of C is expected to be more persistent when it is mediated by fungal biomass and more labile when mediated by bacterial biomass (Van de Werf and Verstraete, 1987). A key feature of natural ecosystems is a soil community dominated by fungal decomposition pathways (Bardgett 1996). In this regard, a study of agricultural grasslands by Yeates *et al.* (1997) suggested that, during the shift from intensive farming to organic management, an indicator of successful transformation into a system based on soil biological processes was a change in the biotic soil community towards fungal dominance. This proposal was based on the finding that in a number of grasslands in the middle of Wales it was found that soil food networks were constantly dominated by bacterial decomposition pathways, while the long-term organic soil systems were dominated by fungi (Yeates *et al.*, 1997). An additional feature of organically managed grassland soil was a high total microbial biomass relative to the soils of intensive grassland systems (Yeates *et al*., 1997). These findings are broadly consistent with those of other studies of different temperate grassland systems that have shown that both total microbial biomass and F/B ratios are higher in long-term unfertilized soils than in fertilized ones (Bardgett *et al*. 1997a). Therefore, in the case of managed grassland systems, detection of a substantial increase in microbial soil biomass and F/B biomass ratio from a defined baseline is an appropriate indicator of effective transformation from a intensive system to a low input system based mainly on self-regulation biological pathways (Bardgett and McAlister, 1999).

Microbial biomass in grasslands is generally higher than in cultivated soils (Adams and Laughlin, 1981). Large microbial biomass in the grassland soil is supported by a large amount of carbon and therefore has a high potential for immobilization of the inorganic N. Expansion of microbial immobilization and subsequent turnover of microbial N are both related to changes in composition and size of microbial biomass. Since bacterial biomass and fungal biomass have C/N ratios of about 5 and 10, respectively (De Ruiter *et al.*, 1993), incremental growth of bacterial biomass will immobilize more N than a similar fungal biomass growth and, therefore, the turnover of a biomass unit in the soil dominated by bacteria will result in a higher mineralization than in the soil dominated by fungi (Bittman *et al*., 2005), also, grazing by fungivores results in a lower mineralization rate than bacterial grazing. In addition, fungal feeding fauna generally has lower biomass and lower rotation rates than bacterial feed (Didden *et al*., 1994). Therefore, a fungal-dominated food network may result in a lower N-mineralization rate. This, however, does not necessarily lead to a lower production. The mycorrhizal biomass probably increases at lower nutrient content in the soil. Their contribution to nutrient absorption can counterbalance the negative effects of low nutrient availability to the crop and thus reduce nutrient losses in the environment (Franciska *et al*., 2006).

Growth of fungal/bacterial biomass ratio in extensively managed grasslands is consistent with other reports (Bailey *et al*., 2002). The mechanisms responsible for changes in the soil microbial community remain largely unknown. Some studies have shown that arable soil management affects the F/B biomass ratio (Frey *et al*., 1999). In most cases, bacteria dominate under conventional tillage, while fungi dominate under no-tillage. This has been attributed to direct contact between bacteria and substrate under conventional tillage, encouraging bacterial growth (Beare *et al*., 1997). Mycelial networks are also destroyed by tillage. The grazing has been reported to be positive

(Bardgett *et al.,* 1997b) or as a negative impact (Ghani *et al*., 2003) on the F/B ratio. Changes in the F/B ratio related to grassland management have been attributed so far to the amount (Mawdsley and Bardgett, 1997) and the quality (Grayston *et al.*, 2001) of root exudations, changes in the quality and quantity of animal faeces and litter (Bardgett *et al.*, 1996) and plant productivity and composition (Donnison *et al*., 2000). F/B ratios may also be affected by other factors, e.g. toxic metals (Tobor-Kaplon *et al*., 2005). Most of these factors are linked to the availability of nutrients. Bittman *et al.* (2005) found a decrease in fungal biomass due to the application of manure and fertilizers. Inorganic nitrogen fertilization has been reported to reduce the F/B biomass (Bloem and Vos., 2004), while organic matter with a high C/N ratio stimulates fungal growth and thus increases the F/B ratio (Vinten *et al*., 2002; Sandor *et al*., 2011).

The pH had a positive or negative effect on the F/B ratio (Bååth and Anderson, 2003). It is suggested that higher biomass ratio of fungal/bacterial are indicative of a more sustainable agroecosystem with a lower environmental impact where organic matter decomposition and N mineralization dominate the supply of plant nutrients for growing crops (Yeates *et al*., 1997).

Table 1

Fungal/bacterial ratio changes in different grasslands management strategies

Reference	System	Methodology	Response of soil microbial community
Yeates *et al*. (1997)	Comparison of long-term organic and conventional grassland systems in lowland mid- Wales	PLFA	Total microbial biomass and fungal: bacterial biomass ratio significantly higher in organic than fertilized grassland soils
Bardgett *et al*. (1997a)	Adjacent fertilized and unfertilized meadows in northern England and Wales	PFLA, ergosterol analysis	Total microbial biomass, fungal biomass and fungal:bacterial biomass ratio consistently higher in unfertilized than adjacent fertilized upland meadows
Bardgett *et al*. (1996)	Productive upland grasslands under extensive management (3 years) in South Wales	PLFA	Cessation of fertilizer applications and liming resulted in significant increase in the soil fungal:bacterial biomass ratio
Bardgett *et al*. (1993)	Established upland grasslands in Dentdale, Cumbria	Membrane filtration	Total fungal biomass (hyphal length) was greater in unfertilized than adjacent fertilized grasslands

(Source: Bardgett and McAlister, 1999)

CONCLUSION

The microbial communities respond to soil management, organic matter, and the abiotic environment factors. Grassland management strategies such as mineral fertilization/organic fertilization and conventional tillage/no-tillage can change fungal/bacterial ratio positively or negatively. F/B biomass ratio it is an indicator of effective transformation from an intensive system to a low input system based mainly on self-regulation biological pathways.

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