Applied Soil Ecology 83 (2014) 170–176

Contents lists available at ScienceDirect

Applied Soil Ecology

journal homepage: www.elsevier.com/locate/apsoil

Organic farming fosters agroecosystem functioning in Argentinian temperate soils: Evidence from litter decomposition and soil fauna

Anahí Domínguez[a,b,*], José Camilo Bedano[a,b], Analía Rosa Becker[b], Romina Vanesa Arolfo[a,b]

[a] CONICET – National Council for Scientific and Technical Research, Argentina
[b] Department of Geology, National University of Río Cuarto, Argentina

ARTICLE INFO

Article history:
Received 30 December 2012
Received in revised form 23 October 2013
Accepted 8 November 2013
Available online 19 December 2013

Keywords:
Ecosystem services
Organic agriculture
Conventional agriculture
Litter decomposition
Soil macrofauna
Soil mesofauna

ABSTRACT

Benefits of organic farming on soil fauna have been widely observed and this has led to consider organic farming as a potential approach to reduce the environmental impact of conventional agriculture. However, there is still little evidence from field conditions about direct benefits of organic agriculture on soil ecosystem functioning. Hence, the aims of this study were to compare the effect of organic farming versus conventional farming on litter decomposition and to study how this process is affected by soil meso- and macrofauna abundances. Systems studied were: (1) organic farming with conventional tillage (ORG), (2) conventional farming with conventional tillage (CT), (3) conventional farming under no-tillage (NT), and (4) natural grassland as control system (GR). Decomposition was determined under field conditions by measuring weight loss in litterbags. Soil meso- and macrofauna contribution on decomposition was evaluated both by different mesh sizes and by assessing their abundances in the soil. Litter decomposition was always significantly higher after 9 and 12 months in ORG than in CT and NT (from 2 to 5 times in average), regardless decomposer community composition and litter type. Besides, mesofauna, macrofauna and earthworm abundances were significantly higher in ORG than in NT and CT (from 1.6 to 3.8, 1.7 to 2.3 and 16 to 25 times in average, respectively for each group). These results are especially relevant firstly because the positive effect of ORG in a key soil process has been proved under field conditions, being the first direct evidence that organic farming enhances the decomposition process. And secondly because the extensive organic system analyzed here did not include several practices which have been recognized as particularly positive for soil biota (e.g. manure use, low tillage intensity and high crop diversity). So, this research suggests that even when those practices are not applied, the non-use of agrochemicals is enough to produce positive changes in soil fauna and so in decomposition dynamics. Therefore, the adoption of organic system in an extensive way can also be suggested to farmers in order to improve ecosystem functioning and consequently to achieve better soil conditions for crop production.

1. Introduction

In the last decades, the spread of croplands has been associated with an unprecedented level of environmental degradation (Barrios, 2007; Foley et al., 2011). This situation has become noticeable in Argentina (e.g. Cantú et al., 2001; Bedano et al., 2006; Bedano and Ruf, 2007; Domínguez et al., 2010), where there has been a marked process of "agriculturization" characterized by a strong and continuous increase in the land area dedicated to crop production. Moreover, the adoption of no-till agriculture, covering in 2011 a 78.5% of the total cultivated area, has been accompanied by an impressive expansion of the genetically modified soybean tolerant to glyphosate, reducing the area devoted to other crops, pastures, and forests (Manuel-Navarrete et al., 2007; AAPRESID, 2012). The agriculturization process has had social and environmental effects. Small and medium farmers are disappearing, and as a consequence, traditional knowledge, rural culture, particular ways of living, and production schemes are also lost (Manuel-Navarrete et al., 2007). A decrease of fauna abundances and diversity has been recorded (Bedano et al., 2006; Bedano and Ruf, 2007; Arolfo et al., 2010; Domínguez et al., 2010), together with soil physical and chemical degradation (Cantú and Becker, 1999).

The situation previously outlined has posed great challenges, such as the need to find alternative farming systems so as to avoid negative social consequences and to allow soil biodiversity conservation. Organic farming has been proposed as one of such

* Corresponding author at: Ruta 36, Km. 601, X5804BYA Río Cuarto, Córdoba, Argentina. Tel.: +54 358 4676229; fax: +54 358 4676530.
E-mail addresses: adominguez@exa.unrc.edu.ar, adominguez.unrc@gmail.com (A. Domínguez).

0929-1393/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.apsoil.2013.11.008

alternative farming system (IFOAM, 2012). Given the vast land areas cultivated in Argentina, this system is commonly practiced in an extensive way. Thus, there are several similarities between organic farming and conventional farming; for example, in both cases farms are large-scale, with low crop rotation and low crop diversity. Although large-scale organic farming may have fewer social interest than agroecological small holder farming systems, it may have significant consequences for the reduction of environmental pollution and the conservation of soil biodiversity and, therefore, for the maintenance of soil ecosystem functioning (Barrios, 2007). However, direct benefits of organic farming to key soil processes, such as plant litter decomposition, and their relation to soil fauna communities, still remain unclear. There is particularly little evidence on contexts of organic farming with high tillage intensity and low crop diversity.

Litter decomposition is one of the most important ecosystem processes performed by soil organisms as it represents the catabolic complement of photosynthesis (Barrios, 2007). It is defined as the ecosystem process that converts plant material into easily accessible inorganic compounds used by soil heterotrophs and plants (Cebrian, 1999; Wilkinson, 2006). Under given climatic conditions, decomposition is governed by several factors, such as litter quality, litter placement and soil organisms. Litter quality affects decomposition in terms of both residue degradability and feeding preferences of the decomposer community for residue originated in situ, an effect that has been called 'home field advantage' (Ayres et al., 2009). Buried litter decomposes faster than surface litter, mainly because when buried it maintains higher water content and supports greater densities of microflora and fauna (Beare et al., 1992). Soil organisms also control decomposition, with soil fauna mainly feeding on and digesting the detritus, and with fungi and bacteria degrading and metabolizing litter components within a complex food web (Cotrufo et al., 2009). Through predation soil fauna also controls the abundance and diversity of the microbial community which is the real 'decomposition engine' (Cotrufo et al., 2009). Indeed, several studies have documented the importance of soil mesofauna and macrofauna for the decomposition process, and have also informed about higher decomposition rates when soil macrofauna is involved in the decomposition process (e.g. Beare et al., 1997; Ke et al., 2005; Milton and Kaspari, 2007).

Benefits of organic farming for soil biota development have been frequently reported (e.g. Bettiol et al., 2002; Birkhofer et al., 2008; Osler et al., 2008), however, studies comparing under field conditions decomposition dynamics between organic agriculture and conventional agriculture, including tillage variants, are very scarce. Most of the research has compared conventional farming (i.e. with agrochemical use) with or without tillage (e.g. Beare et al., 1997) and also conventional farming with organic farming, both using conventional tillage (e.g. Fließbach et al., 2000). Studies which deal with the contribution of different components of the soil fauna to the decomposition process are also scarce, especially in agricultural systems.

The aims of the present research were to analyze the effect of organic farming versus conventional farming (under both conventional tillage and no-tillage) on the litter decomposition process and to analyze how this process is affected by soil meso and macrofauna abundances. Our general hypothesis is that the litter decomposition process would be driven by the interaction of agricultural management, decomposer fauna community, litter type and time of field exposure. Specifically, we hypothesize that (1) organic management would enhance higher litter decomposition than conventional management systems; (2) management systems involving conventional tillage would enhance higher decomposition rate than no-tillage management; (3) higher decomposition would be positively related to higher soil meso and macrofauna abundances; (4) the contribution of macrofauna would increase decomposition; and (5) the local litter in each field would decompose more rapidly than an allochthonous litter.

2. Materials and methods

2.1. Study area

The experiment was conducted during 2009 and 2010 in the south of Córdoba province, Argentina (33°17′ and 32°21′ S; 63°54′ and 63°46′ W). Soil is a loamy, illitic, thermic Typic Haplustoll (Soil Survey Staff, 2010). The climate is sub humid temperate with a dry season in winter; mean annual rainfall is 840 mm and mean annual temperature is 17 °C. However, annual rainfall in both sampled years was slightly lower than the mean, being 638 mm in 2009 and 734 mm in 2010. To control for variation in climate and soil characteristics, eight sites located at a maximum distance of 10 km from one another were selected.

2.2. Characterization of farming practices

The following management systems were studied: (1) organic farming with conventional tillage and occasional grazing (ORG), (2) conventional farming with agrochemical use and conventional tillage (CT), and (3) conventional farming with agrochemical use and no-tillage (NT). The three management systems were represented by two fields (replications), each of at least 25 ha in area. Detailed management practices of agricultural fields are presented in Table 1. As we used non-experimental plots, there were differences in crop rotation because crop history depended on farmers decisions. Non-experimental plots were chosen to study real agricultural systems of the region. In addition, two natural grasslands (GR) of about 0.5 ha were included in the study as reference sites. These natural sites have been undisturbed and covered with natural pastures for the last 50 years. The plant community belongs to the Pampean phytogeographic province (Cabrera, 1976). The community was dominated by *Stipa* sp and also species belonging to the genera *Brassica*, *Oxalis*, *Eragrostis*, *Poa*, *Panicum*, and *Rapistrum* were present. Plant cover was 100% and the litter layer was approximately 1 cm thick. These sites were not managed; they had only had occasional grazing.

2.3. Litter decomposition measurement

Litter decomposition was determined under field conditions by measuring weight loss in vegetal litter inside nylon mesh bags. This technique has been critically evaluated (Prescott, 2005), mainly because the confining of litter generates different field conditions from the natural ones and because it tends to underestimate decomposition (Coleman et al., 2004). Sometimes, decomposition may be overestimated if large mesh sizes are used to evaluate fauna contribution (Graca et al., 2005). However, the scientific community agrees that this methodology is simple and useful especially for comparative studies, where methodological errors are similar (e.g. Graca et al., 2005; OECD, 2006; Berg and McClaugherty, 2008). Also, Lavelle et al. (2006) recognized that the faunal contribution in nutrient cycling must be assessed by litterbag decomposition studies.

In this research, two litter types were used to fill the litterbags: the local senescent litter of each field and a control litter (*Sorghum halepensis* in all fields). Since one of the major effects of crop type on the decomposition process is the chemical quality of supplied residues, the inclusion of a control litter helps to preclude to certain extent the possible effect of different crop rotations between the evaluated sites. It also enables us to evaluate whether or not decomposer community prefers litter originated in situ. All litter types were air-dried at 30 °C for 72 h before litterbag construction.