Applied Soil Ecology 119 (2017) 8–17

Contents lists available at ScienceDirect

Applied Soil Ecology

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

Effect of soil preparation techniques on the biochemical properties and microbial communities of a citrus orchard after replanting and conversion into organic management

Ana Pérez-Piqueres[a], Remedios Albiach[a], Alfons Domínguez[b], Rodolfo Canet[a,*]

[a] Centro para el Desarrollo de la Agricultura Sostenible, Instituto Valenciano de Investigaciones Agrarias (CDAS-IVIA), Apartado oficial, 46113, Moncada, Spain
[b] Estación Experimental Agraria de Carcaixent, Instituto Valenciano de Investigaciones Agrarias, Partida del Barranquet s/n., 46740, Carcaixent, Spain

ARTICLE INFO

Keywords:
Soil enzymes
Microbial biomass
Organic farming
Preplanting
Citrus
Soil suppressiveness to diseases

ABSTRACT

Adequate levels of organic matter and biological activity in soil under organic management are key for crop nutrition and protection against soil-borne pathogens. Before replanting, soil must therefore be prepared accordingly. In this study, the effects of commonly used techniques (vegetal cover, organic amendment, solarization and organic amendment + solarization) on the main biochemical properties and microbial communities of a replanted organic citrus soil were investigated during a full season. The results clearly showed negative solarization effects that degraded the soil organic matrix by the moisture and heat combination, which affected all enzyme activities, save chitinase. These effects were particularly severe and long-lasting for ammonium oxidation-related activities and communities. Solarization was also the main factor to affect soil microbial communities, although differences between treatments disappeared in 6 months, save *Bacillus*-like bacteria. Given that nutrient cycling is essential for fertilisation in organic cropping, caution must be taken when considering the use of solarization to reduce pathogens from soil.

1. Introduction

Adequate levels of soil biological activity and diversity are paramount in organic farming. Not only does crop nutrition largely rely on the biological decomposition of organic materials, but also soil suppressiveness to diseases, which originates from several biological mechanisms, and is arguably the most important defence against soil-borne pathogens. As conventional soils usually have lower levels of biological activity than those in soils under organic management (Albiach et al., 1999; Ge et al., 2013; van Diepeningen et al., 2006), conversion period may be problematic since soil has conventional characteristics, but the agrosystem can be managed only with organic techniques. As replanting is particularly delicate given the susceptibility of plantlets to pathogens, soil disinfection treatments must usually be applied beforehand.

Despite being authorised in organic farming, some of these disinfection methods are known to damage soil biological activity; e.g., heat-based techniques such as steam disinfection (Roux-Michollet et al., 2008) and solarization (Bonanomi et al., 2008; Pane et al., 2012; Scopa et al., 2008) have been shown to bring about detrimental changes in soil microbial biomass and structure. The methodologies that rely totally or partially on fresh organic matter applications could, therefore, be preferable to lessen the impact of disinfection on soil properties. There are no doubts about the intimate relationship between soil organic matter and biological activity. Many studies with bioindicators have shown that applying organic materials directly or indirectly enhances soil biological activity (Diacono and Montemurro, 2010). The result of this enhanced activity is increased soil suppressiveness to diseases as this capacity is based partially on competition for resources. Nevertheless, the main disinfection mechanism involved in these methodologies is the release of volatile substances during decomposition (Klein et al., 2011). The term biofumigation was coined in the early 1990s to identify methods to suppress soil-borne pests by releasing volatile isothiocyanates from the decomposing residues of some *Brassica* species (Angus et al., 1994). Nowadays however, it is routinely used for all practices that involve using fresh organic matter, including those based on releasing ammonia from N-rich residues as a disinfecting agent (Arnault et al., 2013; Martínez et al., 2012). Solarization and biofumigation are often combined for the twofold purpose of enhancing disinfection and reducing damage to soil organic and biological components (Nuñez-Zofío et al., 2012; Núñez-Zofío et al., 2013). During solarization, the degradation rates of organic waste residues are

* Corresponding author.
E-mail address: canet_rod@gva.es (R. Canet).

http://dx.doi.org/10.1016/j.apsoil.2017.05.015
Received 1 December 2016; Accepted 12 May 2017
Available online 06 June 2017
0929-1393/

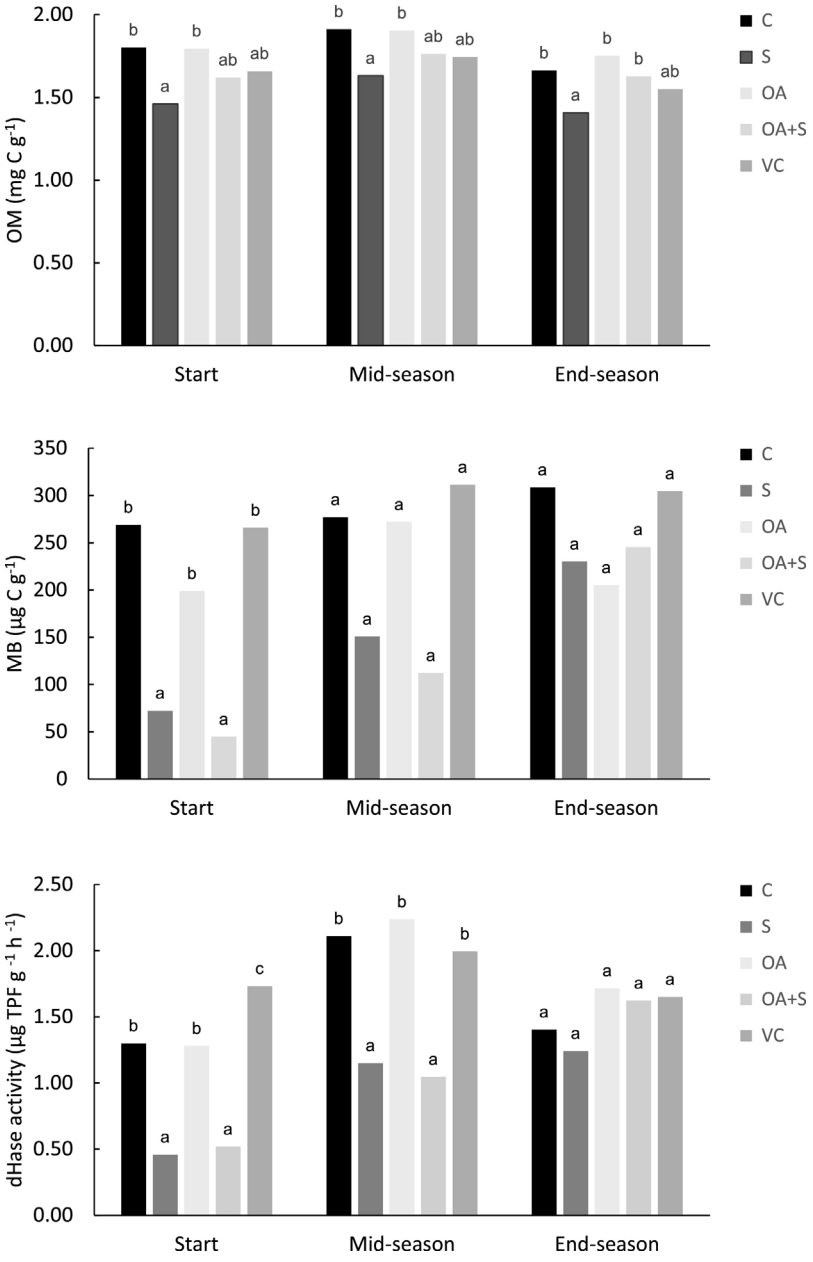

Fig. 1. Content of organic matter (OM), microbial biomass (MB), and dehydrogenase activity (dHase) in soils after treatments: control (C), solarization (S), organic amendment (OA), organic amendment + solarization (OA + S), vegetal covers (VC). Values in the bars with the same letter are not significantly different according to LSD Multiple Range Test at the 0.05 level of probability.

increased by higher temperature and soil moisture, and the disinfection action of volatile substances is strengthened by confinement under the plastic layer that soil is covered with. Moreover, organic matter and the microbial community within residues compensate the reductions in both parameters that solarization may cause in soil (Gelsomino et al., 2006; Pane et al., 2012; Núñez-Zofío et al., 2013).

Despite all this information, there are many factors that strongly influence the success of these practices, such as edaphoclimatic variables, which affect biological activity in soil, the availability and characteristics of local organic materials, or legislative limits, which must be respected in different areas, such as the maximum amounts of nitrogen that can be applied to organic farming. More information that links local conditions and management practices to changes in relevant soil properties is, therefore, necessary to ensure the most beneficial results without harming agrosystems.

Cultural practices are known to strongly influence soil quality and disease suppressiveness (Janvier et al., 2007). Several factors have been proposed as soil quality components, and methods are variable to measure some of them. Among these numerous factors, it is important to be able to select the most interesting ones as indicators because they are fundamental to choose the most adequate soil management. Although the impact of agronomic practices on soil quality has been customarily evaluated by determining soil physicochemical variables, soil biological properties related to the quantity, structure, diversity and activity of soil microbial communities are increasingly being used for their sensitivity, rapid response and ecological relevance (Núñez-Zofío et al., 2012). In organic farming, soil biological activity indices, especially those based on enzymatic activities in connection with nutrient cycles, are particularly interesting as they reflect soil functioning (Canet et al., 2000). In this work, the effects on different bioindicators, soil microbial communities and soil biochemical properties of several commonly used practices to prepare soil before replanting in Mediterranean organic orchards were investigated during a full cropping season.

2. Materials and methods

This study was carried out in a field trial set in an 1.2-ha orchard on