Agroecological Service Crops as a tool to manage the agrobiodiversity in organic orange orchards: a case study

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Key words: weed management, pest management, no tillage, system re-design, agroecology, biodiversity indices

Abstract

The ITACA project "Technical and scientific answers to new orchards converting to Organic Agriculture", a two-years project financed by the Italian Ministry of Agriculture (2014-2015) intended to verify the effect of agroecological service crops (ASC) on the agrobiodiversity in a young orange-orchard. This paper analyzes the role of ASC species and the termination strategy on weeds and fungal communities. The results show a shift of the biodiversity indices of the analyzed community in function of the compared managements.

Introduction

Ecological agriculture aims to build the strengths of natural ecosystems into agroecosystems using practices that (a) grow healthy plants able to resist to enemies, (b) stress pests, and (c) enhance populations of beneficial organisms (Magdoff, 2007). Examples of agroecological practices are the use of cover crops and reduced tillage. Cover crops contribute to optimize nutrient and water cycles, and provides ecological services such as weed and pest management by influencing the agrobiodiversity. By this, cover crops are defined Agroecological Service Crops (ASC). Moreover, reduced tillage increases biota activity in soil, reducing soil organic matter depletion and risk of erosion (Wezel et al., 2014). In order to design a resilient organic citrus system, two ASC species and two termination strategies were compared in an organic orange long-term experiment in Sicily. The work aims at evaluate the ASC effect on system biodiversity in terms of soil fungal-oomycetes and weed communities.

Material and methods

The research was carried out during 2013-2014 and 2014-2015 (hereafter reported as 2014 and 2015, respectively) in the 'Long term trial on organic Citrus' (PALAP9), within the experimental farm of the Research Centre for Olive, Citrus and Tree Fruit of the Council for Agricultural Research and Economics (CREA-ACM) in Sicily (37°17′N, 14°50′E). Orange trees [*Citrus sinensis* (L.) Osbeck] cv. "Tarocco Rosso" grafted on Carrizo citrange rootstock [*Poncirus trifoliata* (L.) Raf. × *C. sinensis* (L.) Osbeck] were planted in June 2012. The experimental design was a split-plot with two factors and three replications. The main factor was the ASC species introduction (ASC): (*i*) no ASC or control (no ASC), (*ii*) Barley, *Hordeum vulgare* L.(B), and (*iii*) Horse bean, *Vicia faba* L. var. *minor* (FB). The split-plot factor was the ASC termination strategy (T): (*i*) incorporation into the soil (GM), and (*ii*) flattening by roller crimper (RC). Each elemental plot was 72 m^2 (12 plants per plot). ASC species were sown on 25 and 24 November in 2013 and 2014, respectively, and they were terminated on 15 and 16 April in 2014 and 2015, respectively.
The evaluation of the weed and soil fungal and oomycetes communities was performed both during the cover crop cycle and after their termination in two phases: 91 and 93 DAS (Days after ASC

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Sowing) and 79 and 84 DAT (Days after ASC Termination) in 2014 and 2015, respectively. The weed density and coverage – total and at species level – was recorded by placing ten randomly-selected 0.25 x 0.25 m^2 quadrats within each plot in the row and inter-row spaces for density determination and selecting three 6.0 x 4.0 m^2 areas for coverage assessment, obtaining a representative sample per plot. The soil samples for mycological determination were collected around the rhizosphere of citrus plants (at the distance of 40 cm from each plant), to a depth of 0-40 cm. Two sub-samples were taken (in the row and between the rows) from rhizosphere soil of each plant; each sample weighed 400 grams. The two sub-samples were subsequently mixed, as to obtain a single homogeneous and representative sample on which the mycological analyses were performed. For each different ASC species and for each different termination strategy, 3 plants were considered, for a total of 48 citrus plants. The soil samples were analyzed for enumeration and identification of fungi and oomycetes, as provided by *Metodi di analisi microbiologica del suolo* (2002). Ten grams soil, wet weight, per each sample was diluted in 90 mL of sterile phosphate buffer and then serial decimal dilutions were prepared. One mL of each dilution was added to 20 mL of agar technical medium containing streptomycin sulfate (200 mgL^{-1}) in order to prevent the bacteria development. Agar plates were incubated at 25°C for 4 days. After incubation distinct colonies were counted and the number of Colony Forming Units (CFU) in a gram sample was calculated. Fungi and oomycetes were identified to genus level according to morphological features.

The weed and mycological biodiversity was evaluated by calculating diversity indices: species and genre Richness (R-weeds; R-fungi), Shannon-Weaver (SW-weeds; SW-fungi) and Dominance-Simpson (D-weeds; D-fungi) (Magurra, 2013). The obtained indices were analysed with a Correspondence Analysis (CA) by using STATISTICA software (StatSoft, Inc. 2007, version 8.0).

Results

The Correspondence Analysis (CA) summarized the variation of the weed and fungi biodiversity indices after ASC sowing (Fig. 1a) and ASC termination (Fig.1b) in the two experimental years. Starting from the 6 tested biodiversity indices, the first two components of CA (Eigenvalue 1: X-axis and Eigenvalue 2: Y-axis) explained about the 98% and 97% of the global experiment variability in the two analysed phases, respectively. The distance among the observations in the scatter chart approximates the dissimilarity of their biodiversity composition. In the first phase (93-91 DAS), this leads to observe that X-axis (85% of explained variability) completely discriminated the Barley (B) species from the other Managements (Fig. 1a). In particular, the plots belonging to barley scored in the right side of the biplot. Differences on the horizontal direction are mainly attributed to R-weeds, SW-weeds and D-fungi characterizing Faba bean (FB) and no ASC, on the negative part, and to R-fungi in the positive part of the axis. Looking to Y-axis (13% of explained variability), the FB species in the first year scored in the lower quadrants of the biplot, while B and control no ASC, scored in the upper ones. Y-axis resulted positively correlated with SW-fungi and SW weeds, and negatively correlated with R-weeds, representing I FB.

In the second phase (79-84 DAT), differences on the X-axis (86% of explained variability) are mainly attributed to R-fungi in 2014 and the II B GM, on the negative part,and to R-weeds and SE-weeds in the positive part of the axis (Fig. 1b). On the other hand, the Y-axis (11% of explained variability), resulted negatively correlated with SW-fungi and D-weeds, and positively correlated with R-fungi. The two years are discriminated with 2014 results positioned in the upper left part of the biplot and the most of 2015 ones in the bottom right side. Exceptions are RC barley in 2014 and GM barley in 2015, bottom right side, and the RC faba bean in 2015, in the upper right side, strongly associated with the R-weeds index.

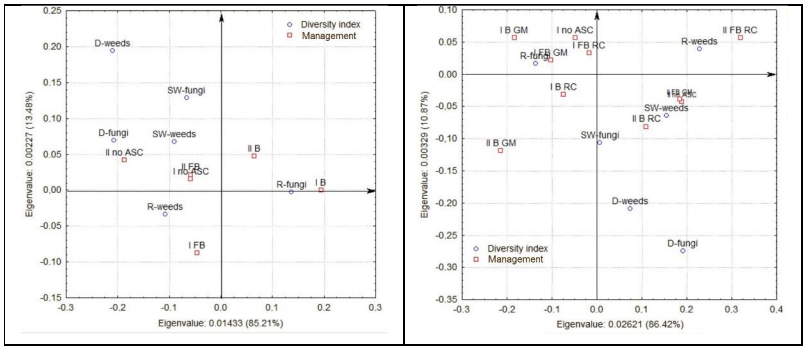

Figure 1: Field trials planning.

Biplots of the corrispondence analysis.

Figure 1a: Eigenvalue 1 (X-axis) explaining 85% and Eigenvalue 2 (Y-axis) explaining the 13% for a total of 98% of the overall variability of the experiment. Management label legend: No ASC, control; FB, faba bean; B, barley; I, 1st year (2014); II, 2nd year (2015). Parameters legend: R-weeds and R-fungi, weed species and fungi genre Richness index; SW-weeds and SW-fungi, weeds and fungi Shannon-Weaver indices; D-weeds and D-fungi, weeds and fungi Dominance-Simpson indices.

Figure 1b: Eigenvalue 1 (X-axis) explaining 86% and Eigenvalue 2 (Y-axis) explaining the 11% for a total of 97% of the overall variability of the experiment. Management label legend: No ASC, control; FB, faba bean; B, barley; I, 1st year (2014); II, 2nd year (2015); GM, ASC termination by green manure; RC, ASC termination by flattening. Parameters legend: R-weeds and R-fungi, weed species and fungi genre Richness index; SW-weeds and SW-fungi, weeds and fungi Shannon-Weaver indices; D-weeds and D-fungi, weeds and fungi Dominance-Simpson indices.

Discussion

Results put in evidence the influence of ASC introduction and termination strategies on the fungal-oomycetes and weed biodiversities in the analyzed phases of the experiment. In particular, in the first phase (93-91 DAS) the barley treatment was characterized by the highest fungal genera Richness and the lowest weed species one. Contrariwise the no ASC and FB were associated to high R-weed. Moreover, the no ASC in 2015 seemed to be also characterized by the highest dominance of few fungal genera and weed species. This result, year depending, confirms the effect of ASC introduction in promoting a lower dominance of species and genera, reducing the risk of selection of infestations, actually ensuring the increase of the system resilience.

As far as the second analysed phase was concerned, results put in evidence the effect of barley in reduce weed Richness and biodiversity and amplify fungi Richness when terminated by green manure, despite the effect of the year. On the other hand, the conservative termination (RC) of barley showed a negative trend with weed Richness (R_weeds) and a positive one with weed biodiversity (SW-weeds), whereas an opposite trend was observed for the flattened faba bean (FB RC).

These trends highlight how farmers can use the ASC and their proper management as a tool for influencing the agrobiodiversity in order to address and manage the services and disservices deriving by its components.

In this perspective, further research are needed to exploit the relationship between the ASC introduction and the plant and microbial communities, fostering the effectiveness of the ASC termination strategies in order to maximize the agroecological services to be provided by ASC species.

Acknowledgments

The authors wish to thank to Biagio Francesco Torrisi and Maria Allegra of CREA—CA for their help in plant and soil analysis. This work was funded by the ITACA research project.

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