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IMPACT OF AGRICULTURAL MANAGEMENT ON COMMUNITIES OF ORIBATIDA, GAMASINA AND COLLEMBOLA IN ITALIAN AND FRENCH VINEYARDS

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Abstract

Quantitative and qualitative analyses among the soil microarthropods can be used in biomonitoring as tools in multi-disciplinary approach to characterize soil quality. Three groups of microarthropods - Collembola and Oribatida as detrivores and Gamasina as predators - were selected to evaluate the impact of different management treatments adopted to recover degraded soil in organic. Differences in arthropod populations between French and Italian sites were registered. In Italy, after two years of recovering treatments, an increase of the abundances of all groups, particularly detritivores in degraded plots, was observed. The population of gamasids increased, in all sites, only in non degraded plots. Soil invertebrates of similar trophic groups, like collembolans and oribatids, seem to differently respond to treatments: the collembolans were more affected by some agronomic practices enhancing soil fertility.

Keywords: *Mites, springtails, sustainable viticulture, organic manure, soil ecosystem*

Introduction

The optimal management of soil fertility is essential to improve agricultural sustainability. FAO considers highly important the issues of soil biodiversity and soil biological processes to achieve resource-efficient and productive agriculture (FAO, 2017). Agricultural practices strongly impact belowground biodiversity to build up long-term soil sustainable productivity; generally these studies were mainly focused on microorganisms (Bender et al., 2016). Last tense, the impact of agronomic managements has been more and more evaluated by deepening studies on microarthropod communities as bioindicators and their contribution to different biological processes especially to breakdown and cycling of nutrients in the soil (Cole 2006; Culliney 2013; De Goede and Brussaard 2002, Gardi et al. 2008; Lavelle et al., 2006; Parisi et al. 2005; Ruf et al. 2006). Natural cover as well as organic residuals coming from crops and plants, below and above ground, are foremost resources for decomposers. In vineyard, i.e. Oribatid mites are strongly impacted by the different mulching techniques (Nannelli and Simoni, 2002)

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showing a negative association with physical and chemical disturbances and low levels of organic matter. Collembola and Oribatid mites inhabiting soils constitute two of the most abundant species of biota (van Straalen, 1998) and they are involved in decomposition of organic matter. Among soil mites, typically predators are Gamasina (Mesostigmata); they can be used as bioindicators due to their high species richness (Koehler, 1999) and to role in controlling function and, consequently, in setting soil food webs (Karg, 1962; Wissuwa *et al*., 2012).
The present study aims: a) to evaluate the impact of agronomic practices enhancing soil fertility on composition and abundances of three main soil microarthropods: Collembola, Oribatida as detrivore functional groups and Gamasina as predator; b) to furnish a useful information in multi-approach evaluation of the management strategies adopted.

Materials and methods

The study was carried on in the context of ReSolVe, a transnational and interdisciplinary 3-years research project aimed at testing the effects of selected organic strategies for restoring optimal soil functionality in degraded areas within vineyard.

Study areas

The experiment involved 2 French and 2 Italian organic farms: Maison Blanche (Montagne St. Emilion) (MB) and Château Pech Redon (Languedoc La Clape) (PR), with climate ranging from Temperate Oceanic to Warm Mediterranean and Cabernet Franc and Syrah as cv, and Fontodi (Panzano in Chianti, Firenze) (FON) and San Disdagio (Roccastrada, Grosseto) (SD), with Warm Mediterranean climate and Sangiovese as *cv*. In each farm, three experimental blocks (250 m^2/block) were defined and subdivided in five plots: three treatments and one control in degraded area, one in no degraded (ND) area. The limits of degraded areas were in correspondence of lower production following the indications of the farmer; the experimental plots have been characterized by soil profile description and analysis with proximal sensing method, namely passive gamma-ray spectroscopy.
In each farm, the first soil sampling was conducted in Spring 2015 before the application of the restoring strategies/treatments: i) compost (COMP; composted manure with or without pruning residues, applied in November 2015 and 2016); ii) green manure (GM; incorporated into the soil in April, or May-June 2016 and 2017); iii) sowing and dry mulching (DM; mowed in May-June 2016 and 2017); iv) tillage with no fertilization as control (CONTR).

Abundance of soil Collembola, Oribatida, Gamasina

For three years (2015-2017), all samplings were collected in Spring. Soil cores (3 replicates, 1 0cm depth, 1dm^3) were sampled using a spade in the middle of the row, before giving the lawn a mow.
Soil microarthropods were extracted by Berlese-Tullgren selectors (25 cm diameter, 2 mm mesh, 60 W lamp at 25 cm distance) for 6 days; all the specimens

collected of Collembola, Oribatida, Mesostigmata were counted at stereomicroscope.

The effect of site (farm), sampling period (year), treatment (management) was evaluated on the respective abundances of Collembola, Gamasina and Oribatida by General Linear Model Analyses (Multivariate approach, SPSS 15.0, 2006). The analysis and post hoc Tukey test comparisons were applied to determine how the experimental solutions on degraded soil affected the abundance of the selected groups of microarthropods.

Results and discussion

The abundances of microarthropod communities' differed concerning the observed groups (Oribatida, Collembola and Gamasina) among the four sites: collembolans ($F_{3,179}$=19.24, $p<0.001$), oribatids ($F_{3,179}$=25.13, $p<0.001$) and gamasids ($F_{3,179}$=15.89, $p<0.001$) showing the highest values in Italian sites. On macro scale, differences are probably due to eco-climatic zone conditions and to complexity levels in eco-mosaic of landscape (e.g. hedgerows, fields, woods, ecc.).

In French farms, during the 3-years sampling period, the application of the different restoring treatments in vineyard soils, in degraded areas, induced significant decreases in mean abundance of all three microarthropod groups (collembolans, oribatids and gamasids) (Figure 1a, b, c).

These results are similar to the observations of Tester (1990), where manuring improved soil properties but altered litter decomposition by affecting the density of decomposers as collembola or oribatid mites. In Italian sites, after two years of treatments, the abundances of the three microarthropod groups were increasing; in particular for detritivores, in degraded plots, this rate was always double for oribatid mites (Figure 1b) and more than six times for collembolans in SD (Figure 1a). Concerning gamasids, in all sites, the increase in abundance was registered only in ND plots (Figure 1c) where no working impact was applied.

The year affected mite comunities, (oribatids: $F_{2,179}$=3.90, $p<0.02$; gamasids: $F_{2,179}$=5.41, $p<0.01$) while did not affect the density of collembolans ($F_{2,179}$=2.36, $P=0.098$). The abundance of oribatids increased along the three years while the highest value for gamasids was registered in the second year. Some authors highlighted the oribatids' role in increasing fertility of soil in different ecosystems (Behan-Pelletier, 1999; Caruso and Migliorini, 2006; Maraun and Scheu, 2000).

In this study, the population dynamics demonstrated effectively resilient trait over the temporal range by implying that tillage methods to recover soil degradation processes are not hindering their density and determining more suitable niches.

The type of soil managements did not significantly affect the two mite groups (oribatids: $F_{4,179}$=1.28, $p=0.281$; gamasids: $F_{4,179}$=0.46, $p=0.766$) (Figure 2); on the other hand, ND, favoured higher collembolan populations ($F_{4,179}$=2.70, $P<0.05$) than in GM and CONTR (Figure 2).

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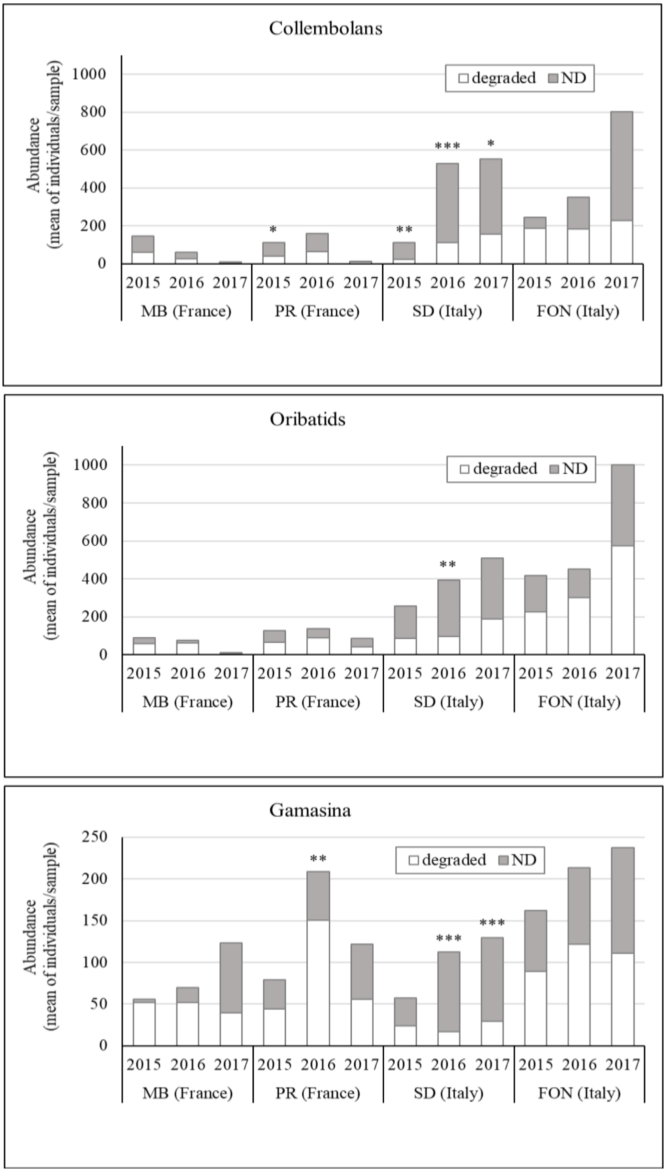

Figure 1

Mean number of Collembola (a), Oribatida (b), Gamasina (c) by different geographical areas, soil conditions (degraded, ND) over the study period.

Within year and site, asterisks indicate difference between soil conditions

*(t-test, *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$)*

Even soil invertebrates of similar trophic groups appear to respond very differently to successional changes (Scheu and Schulz, 1996). Differently from mites, collembolans showed to be more affected by the tillage and by the seedbed: the higher number of individuals in undisturbed soil by confirming the collembolan species showing different preferences in regard to the tillage system or populations' fluctuation in response to changing moisture conditions and abiotic factors (Dittmer and Schrader, 2000).

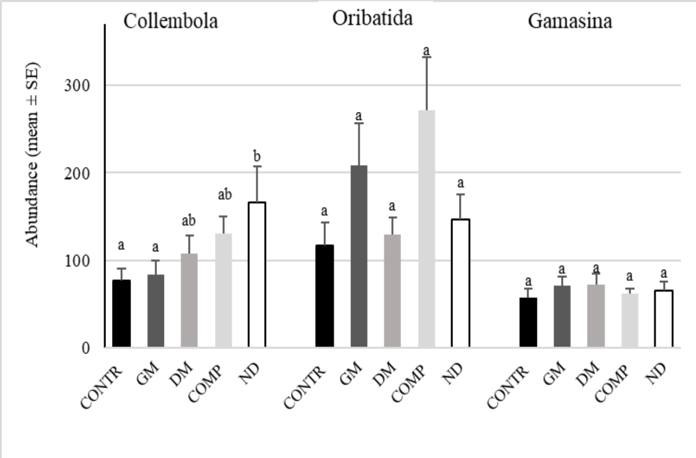

Figure 2

Effect of treatment on the abundance of Collembola, Oribatida and Gamasina.

Within each arthropod group, different letters indicate significant differences (GLM Multivariate approach, Tukey test Post hoc comparison, p<0.05)

Our results suggest that, even following site preparation, the assessment of abundance of the three considered groups of microarthropods can be useful to evaluate the impact of land use and of the recovering agronomic practices. Even if the selected groups are normally representing >80% of the total microarhropods inhabiting topsoil (Gagnarli *et al.*, 2015) and result very sensitive to natural or human induced perturbations, these data should be joined with biodiversity analysis and physical and chemical parameters of the habitat to increase the inference capacity.

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