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NEMATODE COMMUNITIES AS INDICATORS OF SOIL QUALITY IN VINEYARD SYSTEM: A CASE OF STUDY IN DEGRADED AREAS

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Abstract

The restoring effect of selective agronomic strategies on optimal soil functionality of degraded areas within organic vineyard was evaluated using the nematode community as an indicator of soil quality. Three different restoring strategies were implemented in two organic farms located in Tuscany (Italy). The relative abundance of nematode trophic groups and the maturity index showed that the use of compost improved soil biological quality and increased the abundance of predators. Instead, dry mulching and green manure applications were useful to control the most dangerous nematodes of grapevines, namely the virus-vector *Xiphinema index* (Longidoridae).

Keywords: *Free living nematodes, plant parasitic nematodes, dry mulching, green manure, compost*

Introduction

In Italian vineyards, it is quite common to have areas characterized by problems in vine health, grape production and quality, often caused by improper land preparation before vine plantation and/or management. Soil malfunctioning can be caused by reduced contribution of the soil fauna to the ecosystem services such as nutrient cycles and organic matter turnover. At this purpose, biomonitoring and abundance evaluation of soil nematode community represent efficient tools to characterize the effects of crop management by assessing the biological soil quality (Landi et al., 2017; 2018). Soil nematodes play a key role in the soil detritus food web, grazing on bacteria and fungi and thus regulating the decomposition of organic matter. Few studies are available on the whole nematode community associated with vineyard (Malossini et al., 2008; Rhaman et al., 2014). Instead, many studies have been conducted on plant parasitic nematodes that cause serious damages in grapevine areas (Andret-Link et al., 2004; Malossini et al., 2011). The main purpose of the present study was to assess the restoring effect of selective agronomic strategies on optimal soil functionality in organic vineyard from degraded areas using the nematode community as an indicator of soil quality.

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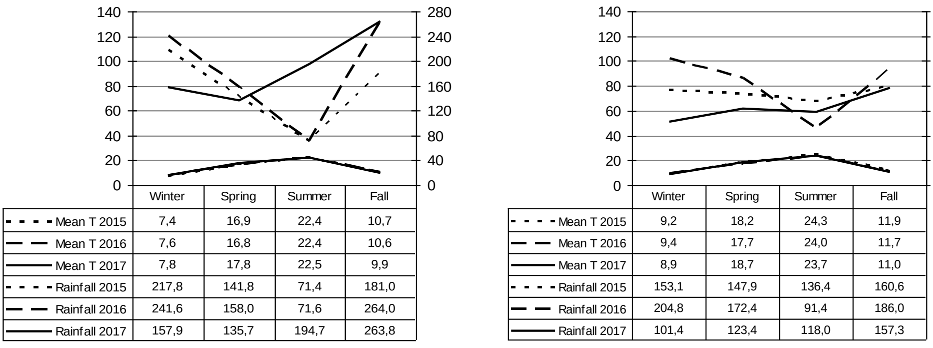
Materials and methods

Field site and treatments description

The vineyards are situated in two commercial farms in Tuscany: i) FON, Fontodi, Panzano in Chianti, Firenze and ii) SD, San Disdagio, Civitella Marittima, Grosseto. Detail are reported by D’Avino (2018). In each farm, three different restoring treatments (DM, dry mulching; GM, green manure; COMP, compost) were compared to a degraded area (CONTR) and a non-degraded area (ND). The different restoring strategies implemented in each plot were: i) compost (COMP) produced on farm *in situ* by manure + pruning residue + grass, ii) faba bean (*Vicia faba* L.) and barley (*Hordeum vulgare* L.) green manure (FAV), iii) sowing and dry mulching with *Trifolium squarrosum* L. (TRI). Detail about experimental plots and description of the treatments was reported by D’Avino et al. (this issue). FON climate was characterized by a mean annual air temperature of 14.4°C with average maximum temperatures observed in July-August 2017 (over 40°C). The tree years average annual precipitation was 700 mm, mostly concentrated in winter for 2015, in winter and autumn for 2016, and autumn for 2017 (Fig. 1). Instead, SD farm climate was characterized by a mean annual air temperature of 15.7°C with average maximum temperatures observed in July-August 2015, and 2017 (over 40°C). The tree years average annual precipitation was only 584 mm, having been the highest rainfall (655 mm) recorded in 2016 mainly from autumn to winter, and the lowest (500 mm) in 2017 mainly in autumn (Fig. 1).



FON (Panzano in Chianti)

	Winter	Spring	Summer	Fall
Mean T 2015	7,4	16,9	22,4	10,7
Mean T 2016	7,6	16,8	22,4	10,6
Mean T 2017	7,8	17,8	22,5	9,9
Rainfall 2015	217,8	141,8	71,4	181,0
Rainfall 2016	241,6	158,0	71,6	264,0
Rainfall 2017	157,9	135,7	194,7	263,8

SD (Civitella Marittima)

	Winter	Spring	Summer	Fall
Mean T 2015	9,2	18,2	24,3	11,9
Mean T 2016	9,4	17,7	24,0	11,7
Mean T 2017	8,9	18,7	23,7	11,0
Rainfall 2015	153,1	147,9	136,4	160,6
Rainfall 2016	204,8	172,4	91,4	186,0
Rainfall 2017	101,4	123,4	118,0	157,3

Figure 1. *Mean air temperature and rainfall in FON and SD in 2015, 2016 and 2017.*

Soil sampling and soil nematode community analysis

Soil samples were collected in each study area in 2015 (before treatments), 2016 (first year of treatment) and 2017 (second year of treatment), in spring in three different points of each plot. Soil sampling was carried out at 0-30 cm depth. The soil nematode extraction was performed by cotton-wood filter method. Nematodes were mounted on temporary slides and identified to genus or family level using taxonomic keys from Mai and Lyon (1962), Bongers (1988), Marinari-Palmisano and Vinciguerra (2014). The members of each family were then assigned to a trophic grouping based on Yeates et al. (1993). Nematode communities were analyzed using relative abundance of trophic groups, and the biological soil quality was evaluated by Maturity Index (MI) and Plant Parasitic index (PPI) (Bongers, 1990).

Statistical analysis

One-way ANOVA was performed to assess the influence of management on relative abundance of nematode trophic groups. Two-way ANOVA was carried out to evaluate the impact of management and year on the indicators of nematode community structure. When the F-test was significant at *P<0.05*, treatment means were compared using Student-Newman-Keuls test using CoStat statistical software package (http://www.Cohort.com/costat.html). The trophic group percentages were arcsine transformed before being statistically analyzed.

Results and discussion

A total of sixteen plant parasitic and free living nematode families were identified. The proportion of nematodes in the feeding groups was similar between sites: bacterial feeders, omnivores and plant parasitic nematodes were the most representative groups, while the abundance of fungal feeders and predators was low (Fig. 2).

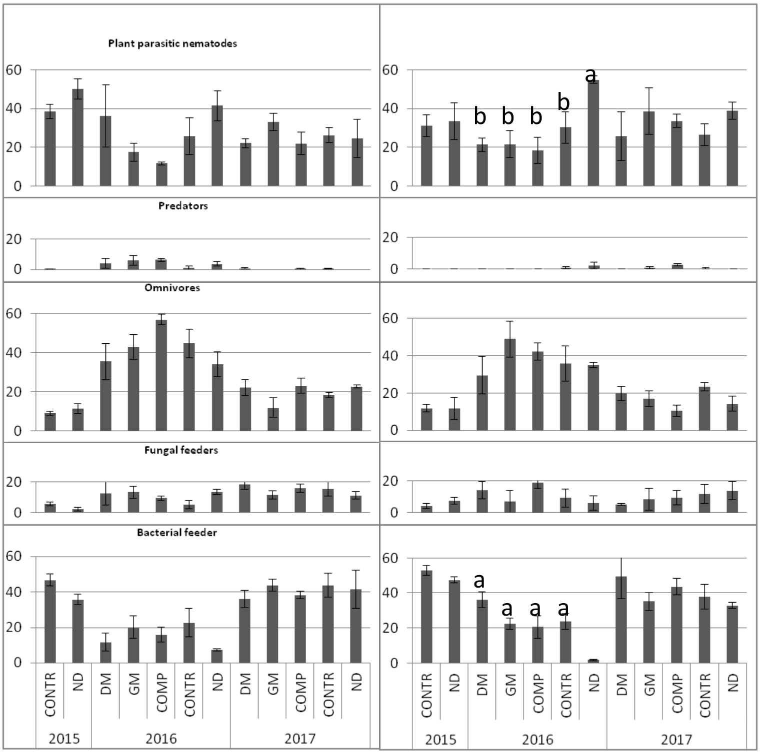


Figure 2
Effects of different managements on relative abundance of nematode trophic groups. Samples were collected during 2015 and 2017 (n=3) from DM, dry mulching; GM, green. Standard errors are reported. Different letters indicate significant differences at P<0.05.

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Bacterial feeder abundance was influenced by rainfall. As previously observed by Rahman et al. (2009), they represented about 50-60% of the total nematode population in the drought years, namely 2015 and 2017. Conversely, the lowest bacterial feeder percentages were found in 2016, mainly in non-degraded areas.
The application of restoration techniques in 2016 increased omnivores and the fungal feeder activity in both sites. Predators significantly increased under COMP in SD and reached 3% of the total nematode population in 2017.
As reported by several authors, benefits provided by the soil application of organic matter on the suppression of plant parasitic nematodes were found (Rahman et al., 2014; Landi et al., 2016). After the first year under organic treatment plant parasitic nematodes significantly decreased in DM, GM and COMP in SD. The plant parasitic composition also was affected by managements. In both sites, Hoplolaimidae family was dominant before restoring, both in degraded and non-degraded soils and the major pest of grapevines, the virus-vector *Xiphinema index* (Longidoridae), was reported only in degraded soil. The application of restoration techniques in 2016 increased Tylenchidae family, in particular *Tylenchorhynchus* genus, in all organic treatments. Concerning *X. index*, no individuals were found in restored soil with cover crops (DM and GM).
With regard to nematode indicators, MI showed a different trend during the years: significantly lower values were found in drought years (2015 and 2017), indicating the great presence of general opportunistic and food web dominated by decomposer bacteria. COMP significantly improved soil biological quality in FON. Instead, no differences were found for PPI both for managements and years.

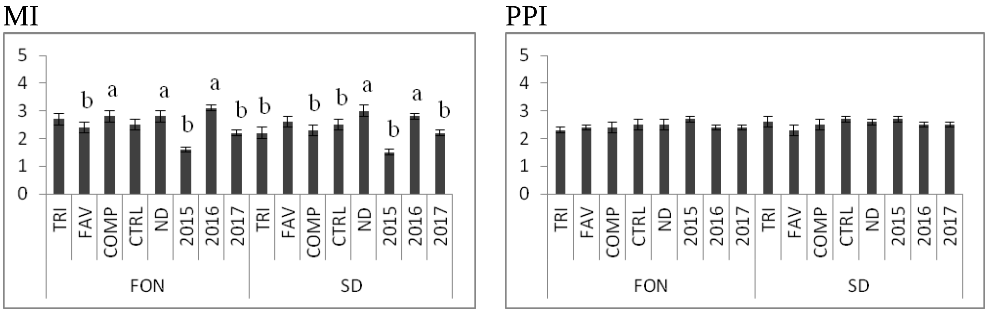

Figure 3. *Effect of soil nematode indices. TRI, dry mulching; FAV, green manure; COMP, compost, CRTL, degraded area; ND, non-degraded area; MI, maturity index; PPI, plant parasitic index. Standard errors are reported. Different letters indicate significant differences at P<0.05.*

Conclusion

Generally, suitability and economics of investigated treatments may vary depending on the regions, crops, and technologies used (Tilman et al., 2002). Indeed, Tardaguile et al. (2018) reported no significant differences in vegetative growth, yield and grape quality among the soil management strategies in degraded areas of this study. On the other hand, the environmental and soil health benefits, such as soil fertility and biodiversity, joined with the reduced chemical inputs and soil erosion is higher in the organic system (Pimentel et al., 2005; Mocali et al., 2015; Landi et al., 2017). The effect of different restoration treatments should be evaluated using long-term monitoring data. However, our preliminary data shown that compost application seems to be promising to improve soil biological quality and increase the abundance of predators. Instead, dry mulching and green manure were effective to reduce the *X. index* population.

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