Soil Phytoparasitic Nematodes Suppression and Changes of Chemical Properties Determined by Waste Residues from Olive Oil Extraction

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Abstract: The effect of olive mill wastes soil amendments on phytoparasitic nematodes and on soil fertility was investigated in a field experiment in southern Italy (Apulia region). Fresh and composted olive pomace were distributed at 10 t/ha, 20 t/ha, 40 t/ha rates and raw sewage was supplied at 40 m^3/ha, 80 m^3/ha, 160 m^3/ha, 240 m^3/ha in a sandy soil (Castellaneta, province of Taranto) infested by *Meloidogyne incognita*. Untreated and 300 kg/ha granular fenamiphos treated soil were also used as control. Cantaloupe crop yield, soil nematode population and root infestation index were recorded. Soil fertility parameters, C and N contents, nitrates and ammonium, total organic, extracted and humified C, were also determined. The results obtained may suggest that incorporation of OWW into the soil results in a suppression of soil nematode populations and, at low initial soil infestation, also in a crop yield increase. On the other hand the soil system is positively affected by the increase of soil organic matter content; perhaps the incorporation into the soil of organic substances containing, as average, 40 % of C, can contribute to C sequestration and to reduce greenhouse effect.
Keywords: control, nematodes, olive mill wastes, soil fertility

1 Introduction

The disposal of olive mill wastes (OMW), fresh pomace and raw sewage, represents a serious environmental problem in the areas of cultivation of olive, as large amounts of these materials are produced in a short period every year (Ranalli and De Mattia, 1996).

Incorporation of these materials into the soil could represent a possible alternative solution for this disposal. Recent studies showed that soil porosity, aggregates stability, hydrological properties were improved by the application of OMW (Pagliai, 1996), although contrasting results derived from previous experiments (Bonari and Ceccarini, 1993).

Moreover, fresh olive pomace was already demonstrated to be suppressive on soil phytoparasitic nematode populations, either in glasshouse or field conditions (D'Addabbo *et al*., 1997; 2000), whereas little information is available on the possible nematicidal effect of raw sewage and composted pomace.

Objective of the field experiment described in this paper was a comparative evaluation of the effect of fresh and composted olive pomace and raw sewage soil application on a population of the root-knot nematode *Meloidogyne incognita* and on the chemical properties of the soil.

2 Material and methods

A sandy soil at Castellaneta, Apulia, infested (3 eggs and juveniles/cm^3 soil) by *Meloidogyne incognita* (Kofoid *et* White) Chitw. was deeply ploughed, rotavated and subdivided in 3.5 m× 3 m plots, spaced 1 m each other and distributed in a randomized block design with five replications of each treatment.

Fresh and composted pomace were distributed on the plot surface on 28 February 2000, at 10 t/ha, 20 t/ha and 40 t/ha rates and then incorporated into the soil at 25 cm — 30 cm depth by rotavation. Raw sewage was added at the dosages of 40 m^3/ha, 80 m^3/ha, 160 m^3/ha and 240 m^3/ha on the same date.

Untreated soil and 300 kg/ha granular fenamiphos, distributed one day before transplanting, were used as controls.

One month old seedlings of cantaloupe (*Cucumis melo* L.), cv. Gialletto rugoso di Cosenza, were transplanted in the plots at a spacing of 1.25 m in the row and 1.5 m between rows, 4 plants per plot, on 24 May. During the growing season the field received the usual cultural practices.

Fruits were harvested on 28 July and 6 August and their weight recorded. Root gall index, according to a scale from 0 (no galls) to 5 (root system completely deformed by large galls) was determined on August 10 on all the plants in the plots (Di Vito *et al*., 1979). Soil samples in a composite of twenty four 1.5 cm diam and 30 cm deep cores were collected from each plot on 27 February, before treatments, and again after harvest on 18 August to evaluate chemical changes and nematode population variation in the soil. Nematodes were extracted from 500 cm^3 subsamples by the Coolen's (1979) method and then counted.

Soil N-NO_3, N-NH_4 exchangeable, total organic carbon (TOC), total extracted (TEC) and humified carbon (humic and fulvic acid, $C_{HA} + C_{FA}$) were determined (Sequi *et al*., 1986; Italian Ministry of Agricultural Resources, 1992). The degree of humification, DH% = $(C_{HA} + C_{FA})$/TEC*100, the humification rate, HR% = $(C_{HA} + C_{FA})$/TOC*100, and the humification index, HI= NH / $(C_{HA} + C_{FA})$, were also calculated.

Data were statistically analysed by the analysis of variance and means compared by Duncan's Multiple Range Test (P=0.05).

3 Results and discussion

All the treatments with fresh and composted olive pomace caused a significant increase of cantaloupe yield compared to the untreated control, whereas raw sewage showed a statistical difference only at the highest rate (Table 1). Moreover, no difference resulted among the different doses of each material. Yield of amended plots did not statistically differ from fenamiphos.

Composted pomace suppressed the gall formation on cantaloupe roots also at the lowest dosage, whereas fresh pomace and raw sewage were effective at rates > 10 t/ha and > 40 m^3/ha, respectively.

Soil population of *M. incognita* was significantly reduced by all the amendments which did not result statistically different from fenamiphos. No differences were found among the different amendment rates.

Soil NNO_3 and NNH_4 variations, as affected by experimental treatments, delineate similar trends in treated and untreated plots (Fig.1). A larger increase of exchangeable ammonium of soil was observed after the treatment in comparison to corresponding variations recorded in plots treated with olive mill wastes. All the treatments except fenamiphos determined an increase of total organic carbon in the soil (Fig. 2a). Maximum increase (+ 76%) was observed in plots treated with fresh olive pomace, in which TOC at the harvest (6.63 g/kg soil) resulted significantly higher than untreated control. The highest T.E.C. variations were recorded in plots treated with fresh olive pomace (Fig. 2b), whereas humified C decreased in soil treated with olive mill wastes and increased in the untreated plots (Fig. 2c).

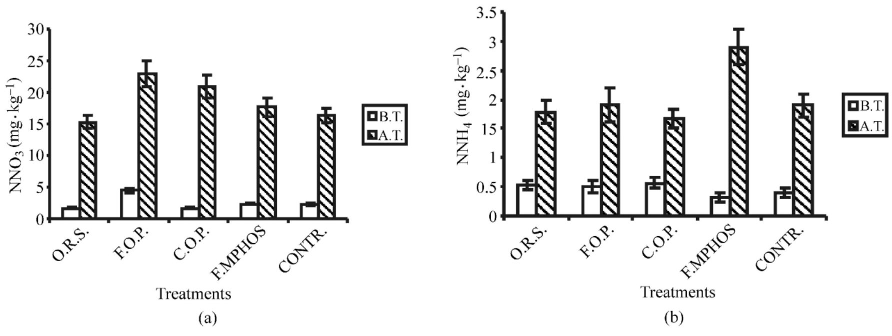


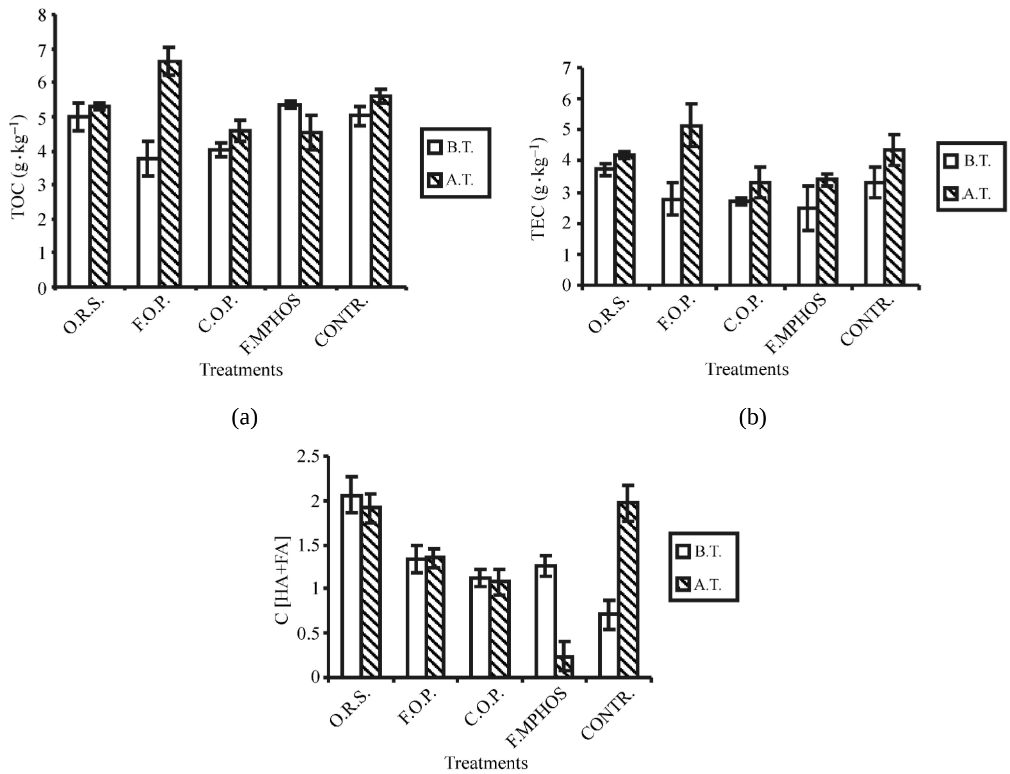
Fig.1 Variations of soil NNO_3 and exchangeable NNH_4 before (B.T.) and after (A.T.) treatments. (O.R.S.= olive raw sewage; F.O.P. = fresh olive pomace; C.O.P. = composted olive pomace; F. MPHOS = fenamiphos and CONTR. = control)

Table 1 The effect of soil amendments with different dosages in soil infested by *Meloidogyne incognita* on the growth of cantaloupe (cv. Gialletto Rugoso di Cosenza)

Treatment	Dosage (m^3 or t/ha)		Yield (kg/plot)		Final nematode population/cm^3 soil	Gall index	
Olive raw sewage	40	15.2(1)	ab(2)	3.3	b	3.5	a
	80	18.8	abc	2.6	ab	2.9	b
	160	20.4	abc	1.8	ab	2.9	b
	240	25.2	bc	1.9	ab	2.7	bc
Fresh olive pomace	10	22.4	bc	2.6	ab	3.3	a
	20	20.0	abc	2.1	ab	2.4	cde
	40	21.2	bc	2.2	ab	2.6	bc
Composted olive pomace	10	29.6	c	2.9	ab	2.2	de
	20	29.6	c	2.7	ab	2.6	bc
	40	27.2	bc	1.7	ab	2.1	e
Fenamiphos	0.3	22.0	bc	1.0	a	2.4	cde
Control (untreated)	---	8.0	a	5.8	c	3.5	a

(1) Each value is an average of five replications;

(2) Data followed by the same letters in any column are not statistically different according to Duncan's Multiple Range Test (P = 0.05).



(c)

Fig.2 Effect of treatments on total, extracted and humified C (B.T. = before treatments; A.T. = after treatments). (O.R.S.= olive raw sewage; F.O.P. = fresh olive pomace; C.O.P. = composted olive pomace; F. MPHOS = fenamiphos and CONTR. = control)

All the three humification indexes were affected by the treatments (Fig. 3): the degree of humification (DH) and, although less evidently, the humification rate (HR) decreased in all the treated plots and increased in untreated soil; the decrease was larger in fenamiphos–treated soil. Humification index (HI) (Fig. 3c) increased by all the treatments, whereas decreased in untreated plots.

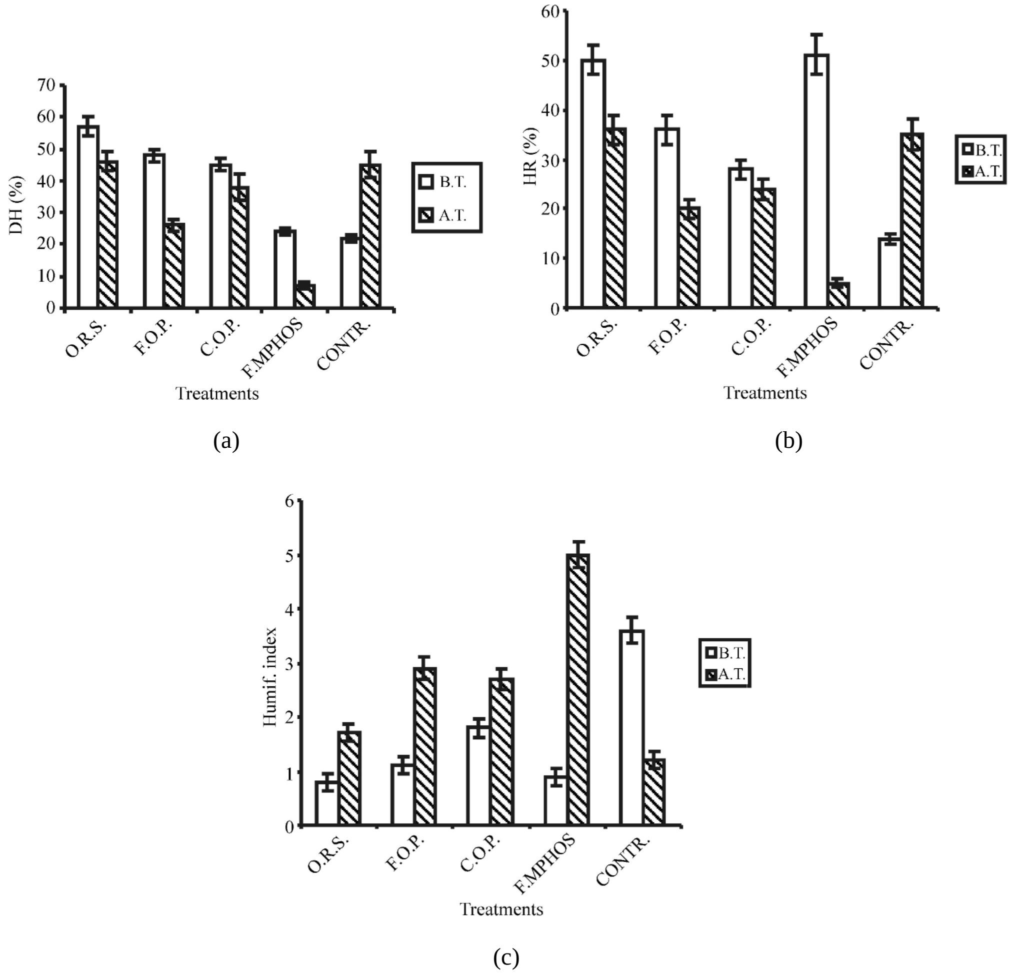


Fig.3 Hunification index variations before (B.T.) and after treatments (A.T.). (O.R.S.= olive raw sewage; F.O.P. = fresh olive pomace; C.O.P. = composted olive pomace; F. MPHOS = fenamiphos and CONTR. = control)

Fresh olive pomace confirmed also in this trial its suppressivity action on *M. incognita*, as previously found in other field experiments (D'Addabbo *et al*., 2000). Raw sewage and composted pomace were found also effective, as their action was similar to fenamiphos. Moreover, also crop yield in amended plots was enhanced at the level of the chemical treated soil.

Presence of the galls on the roots showed that amendments did not prevent the attack of *M. incognita*, resulting only in a remarkable reduction of nematode reproduction.

More generally, the results from this trial and their comparison with those from the previous field experiments may suggest that incorporation of OMW into the soil results in a suppression of soil nematode populations and, at low initial soil infestation, also in a crop yield increase. Therefore, the aim of soil amendments with these materials should be a progressive reduction of infestation level under the tolerance limit of the target nematode species (Sasanelli, 1994).

The alterations in the environment determined by experimental treatments could interest soil pH and oxygen content and, consequently, variations of soil mineral N pool, soil organic C can be determined. Humified C presented a different trend in treated and untreated plots because the fresh organic matter introduced into the soil through OMW decomposed more rapidly during the first few months (Jenkinson, 1981), causing therefore a great C loss, whereas it showed an increase in unamended plots. Fenamiphos treated plots contained very low quantities of humified C, probably because the chemical treatment inhibited the synthesis of typical humification products. In fact fenamiphos, as all organo-phosphoric pesticides, determines a great variation on composition of soil microfauna that transform soil organic matter and, consequently, the natural evolution of soil fertility was modified (Nucifora, 1991).

In conclusion OMW soil amendments could be suggested for integrated nematode management strategies, as it provides a good pest suppressivity reducing the impact on soil — plant equilibrium compared to chemical nematicides. Moreover, the soil system is positively affected by the increase of soil organic matter content, the priming effect and the supply of organic biomass energetically useful for micro-organisms. Finally, the incorporation into the soil of organic substances containing, as average, 40 % of C, can contribute to C sequestration and to reduce greenhouse effect.

Aknowledgements

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