OLIVE POMACE AND CHICKEN MANURE AMENDMENTS FOR CONTROL OF *MELOIDOGYNE INCOGNITA* OVER TWO CROP CYCLES

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ABSTRACT

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The suppressive effect of olive pomace and chicken manure, alone and in combination, was studied in a field infested by *Meloidogyne incognita* on tomato (*Lycopersicon esculentum* Mill.), and cantaloupe (*Cucumis melo* L.) in Southern Italy for two crop cycles. Single application of the two amendments suppressed nematode populations in both years, but more consistently in the second year. Crop yields were also increased in amended plots. The combination of olive pomace with chicken manure enhanced suppressiveness and increased crop yield compared to the single amendments alone.

Key words: amendments, chicken manure, control, *Meloidogyne incognita*, olive pomace.

RESUMEN

D'Addabbo, T., N. Sasanelli, F. Lamberti, P. Greco, and A. Carella. 2003. Enmiendas de orujo de oliva y estiércol de gallina para el control de *Meloidogyne incognita* durante dos ciclos de cultivo. Nematropica 33:1-7.

Se estudió el efecto supresivo del orujo de oliva y estiércol de gallina, individualmente y en combinación, en campos de tomate (*Lycopersicon esculentum* Mill.) y melón (*Cucumis melo* L.) infestados con *Meloidogyne incognita* en el Sur de Italia durante dos ciclos de cultivo. Aplicación simple de cada una de las dos enmiendas redujó las populaciones del nemátodo en ambos años, pero más consistentemente en el segundo año. Además, las cosechas incrementaron en parcelas tratadas con las enmiendas. Comparado con el uso de cada enmienda individualmente la combinación de los dos tipos de enmienda, orujo de oliva y estiércol de gallina, aumentó la supresión del nemátodo e incrementó las cosechas.

Palabras claves: Enmiendas, estiércol de gallina, control, *Meloidogyne incognita*, orujo de oliva.

INTRODUCTION

The effectiveness of olive pomace soil amendments for the control of root-knot nematodes, *Meloidogyne* spp., has been demonstrated in many studies (D'Addabbo and Sasanelli, 1996; Rodriguez-Kabana *et al.*, 1992). Results of pot and microplot glasshouse experiments have shown that the application of olive pomace in combination with organic nitrogen compounds mitigates phytotoxicity at high application rates and enhances nematode suppression (D'Addabbo *et al.*, 2000; Marull *et al.*, 1997; Rodriguez-Kabana, 1995).

However, there is a lack of information on the long term effects of repeated pomace applications on crop yield and soil nematode populations under field conditions. A two-year field experiment was conducted in southern Italy to study the effect of repeated applications of olive pomace for control of root-knot nematodes on tomato (*Lycopersicon esculentum* Mill.) and cantaloupe (*Cucumis melo* L.). Pomace was applied alone or in combination with chicken manure, as an organic nitrogen source, on two consecutive crop cycles. This study also included plots treated with fenamiphos, for comparison with a chemically-treated control.

MATERIALS AND METHODS

The experiment was carried out in a field heavily infested by *M. incognita* (17 eggs and juveniles/cm^3 soil) at Monteroni (Lecce province, southern Italy). The soil texture was 64.4% sand, 18.7% silt, 16.9% clay, 0.8% OM, with a pH of 7.5. The field was divided in 80 12-m^2 plots (3 × 4 m). Plots were spaced 1 m apart and randomly assigned to one of 17 treatment combinations, with five replicates per treatment combination (Tables 1, 2).

Olive pomace (OP) and chicken manure (CM), alone or in combination, were broadcast on the surface of the plots at the rates of 0, 25, 50, and 100 t/ha and 0, 1, 2 and 4 t/ha, respectively, on 16 January 1999. The experimental design was therefore a y x y factorial, with y rates each of OP and CM. The five plots with zero rates of both OP and CM served as non-treated controls. Amendments were incorporated to a depth of 25-30 cm by rotavation. A granular formulation of fenamiphos (formulated as 5G), at 15 kg a.i./ha, was broadcast on the surface of five plots and incorporated to a depth of 10 – 15 cm the day before transplanting. This 17th treatment provided a chemically-treated standard for comparison with other treatments.

One-month-old tomato seedlings of tomato, cv. Tondino, were transplanted on 18 May. There were 36 plants/plot spaced 0.25 m in the row and 1 m between rows. All plots received weed control, fertilizer application, irrigation at rates typical for commercial vegetable production in southern Italy.

Tomatoes were harvested weekly, from 18 August to 16 September, and plot yields were recorded. A root gall index was determined on 21 September for all plants in each plot, according to a 0 – 5 scale, where 0 = no galls, 1 = 1 – 2 galls, 2 = 3 – 10 galls, 3 = 11 – 30 galls, 4 = 31 – 100 galls and 5 = > 100 galls per root system (Taylor and Sasser, 1978). A composite soil sample of 40 cores was collected with a soil probe, 1.5 cm diameter and 30 cm long, in the center square meter of each plot, on 25 September. Eggs and juveniles were extracted from 500 cm^3 aliquots by Coolen's (1979) method and counted.

OP and CM amendments were repeated 24 January 2000 on the same plots. One month old cantaloupe cv. Deloro seedlings (8 plants/plot) were transplanted at a spacing of 0.8 m in the row and 1 m between rows, on 15 May. Fruits were harvested 27 July. Root gall indices were determined 28 July and soil samples were collected the day after and processed as in the previous year, to determine the final nematode population.

Data were analyzed using the generalized linear model procedure of SAS (SAS Institute, Cary, NC). Analysis of variance for a 4 × 4 factorial design was used to examine effects of OP and CM rates and OP × CM interactions. Treatment sum of squares were partitioned into single-degree-of-freedom orthogonal contrasts to examine differences between amendment-treated and untreated or chemical-treated plots, and between OP and CM treated soil. Since the host crop varied each year, the data from each year were analyzed separately.

Table 1. Single-degree-of-freedom contrasts of olive pomace (OP) and chicken manure (CM) treatment vs. untreated control and fenamiphos in 1999 and 2000.

Contrasts	Year 1999				Year 2000			
	Tomato yield		*M. incognita* population at harvest		Cantaloupe yield		*M. incognita* population at harvest	
	F value	P > F	F value	P > F	F value	P > F	F value	P > F
OP vs. untreated	17.95	0.0002	47.25	0.0001	17.18	0.0003	44.05	0.0001
OP vs. fenamiphos	12.43	0.0015	3.33	0.0787	2.72	0.1105	0.13	0.7170
CM vs. untreated	12.85	0.0013	41.20	0.0001	6.62	0.0157	48.00	0.0001
CM vs. fenamiphos	17.45	0.0003	5.20	0.0304	0.01	0.9400	0.01	0.9409
OP vs. CM	4.77	0.0375	4.27	0.0480	1.78	0.1935	0.66	0.4232

Table 2. Factorial analysis of the first year olive pomace (OP) and chicken manure (CM) amendments on tomato yield and *M. incognita* soil population.

	OP rate (t/ha)				
CM rate (t/ha)	0	25	50	100	Mean
	Tomato yield (kg/plot)				
0	53.8	68.6	63.6	67.8	63.4
1.0	64.2	64.0	73.0	77.0	69.5
2.0	65.2	67.4	76.0	88.6	74.3
4.0	64.6	72.6	73.2	86.2	74.1
Mean	61.9	68.1	71.4	79.9	—
0 + Fenamiphos	78.0	—	—	—	—
ANOVA F values:					
OP rate	24.96 **				
CM rate	10.84 **				
OP × CM	2.23 *				
	M. incognita population at harvest (Eggs and J2/cm^3 soil)				
0	49.1	27.6	26.8	25.5	32.2
1.0	37.9	25.4	20.4	16.0	24.9
2.0	26.1	23.2	21.0	14.5	21.2
4.0	20.4	23.0	20.6	11.3	18.8
Mean	33.4	24.8	22.2	16.8	—
0 + Fenamiphos	20.7	—	—	—	—
ANOVA F values:					
OP rate	25.57 **				
CM rate	18.51 **				
OP × CM	3.44 **				

* = F values significant at P = 0.05; ** = F values significant at P = 0.01.

RESULTS AND DISCUSSION

In the first year, both amendments suppressed ($P < 0.01$) *M. incognita* population compared to the untreated control (Table 1). Final nematode population in fenamiphos-treated plots was lower ($P \leq 0.01$) than CM, but no significant difference (at $P = 0.01$) was found with OP. Main effects of OP and CM rates and OP × CM interaction effect were highly significant (Table 2).

Tomato yield of OP and CM amended plots was higher ($P < 0.01$) than untreated soil, but lower than fenamiphos. Moreover, crop yield was significantly affected by the amendment rates and their interaction.

In the second year, either OP or CM suppressed ($P < 0.01$) final nematode soil population in comparison with the untreated soil and did not show statistical differences from fenamiphos (Table 1). Main effects of OP and CM rates and their interaction effect on soil nematode densities were found significant either at transplanting or at the end of the experiment (Table 3). Since amendments interacted with each other, a multiple nonlinear relationship among OP and CM rates and nematode population level at transplanting was fitted to the data. The best fit to the experimental data was given by the equation:

$$y = 6.66 - 0.08002\, x_1 - 5.203\, x_2 - (8.024 \times 10^{-5}) x_1 2 + 2.374\, x_2 2 + 0.04547\, x_1\, x_2 + (5.189 \times 10^{-6}) x_1 3 - 0.0001417\, x_1 2\, x_2 - 0.005162\, x_1\, x_2 2 - 0.3325\, x_2 3$$

in which: y = nematode population at transplanting; x_1 = OP rate; x_2 = CM rate. The coefficient of determination, R^2 = 0.845 (F = 3.38, $P < 0.01$), indicates that 84.5% of the total variation in the nematode population at transplanting was explained by the above relationship.

Significant increases of cantaloupe yield were obtained in OP and CM amended soil compared to the untreated control, whereas no statistical differences in yield resulted between fenamiphos-treated and amendment-treated plots. Both OP and CM rates affected crop yield, but no significant interaction effect was found.

Results from this experiment confirmed the suppressivity of OP on *M. incognita*, previously reported in other trials (D'Addabbo and Sasanelli, 1996; D'Addabbo *et al.*, 2000), suggesting also that this suppressive action is related to OP rates. Moreover, a positive effect of pomace on crop yield was also observed.

No phytotoxic effect was observed in OP amended plots in either year. Absence of phytotoxicity, as previously reported (Rodriguez-Kabana *et al.*, 1992; 1995), could possibly be explained by the longer interval between OP incorporation and transplanting (only 12 days in the above cited experiments vs. 4 months in the current experiment), which probably allowed degradation of phytotoxic components.

Application of chicken manure alone resulted in a suppressive action on the root-knot nematode population, related to amendment rates, but at rates lower than those previously reported in the literature (Rodriguez-Kabana, 1986; Kaplan and Noe, 1993). Application of CM positively affected also the crop yield, depending on incorporation rates. However, this yield increase, already known from other experiments (Chindo and Khan, 1990), may have been from a fertilizer effect of CM as well as from nematode suppression, or from a combination of the two mechanisms.

Combination of the two amendments resulted in a higher nematode suppression and a better crop yield compared to single application of either of them. This was also observed in experiments by Marull *et al.* (1997), in which combined pomace and chicken litter treatments induced the highest tomato yield. Therefore mixtures of these materials seem to be more suitable to optimize the beneficial effects from these amendment treatments.

The low nematode population levels observed at the beginning of the second crop cycle indicated that the suppressive influence of pomace on nematode population should not be evaluated in a single crop cycle. The amendment degradation and consequent modification of soil microflora involved in the nematode antagonistic effect occurred over more than one crop cycle. Pomace amendments,

Table 3. Factorial analysis of the second year olive pomace (OP) and chicken manure (CM) amendments on cantaloupe (cv. Deloro) yield and *M. incognita* soil population.

	OP rate (t/ha)				
CM rate (t/ha)	0	25	50	100	Mean
	Cantaloupe yield (kg/plot)				
0	4.5	8.6	11.7	22.6	11.8
1.0	6.6	12.1	15.7	30.7	16.3
2.0	8.3	15.4	23.7	35.9	20.8
4.0	17.0	20.3	34.3	36.1	26.9
Mean	9.1	14.1	21.3	31.3	—
0 + Fenamiphos	10.4	—	—	—	—
ANOVA F values:					
OP rate	68.31 **				
CM rate	25.36 **				
OP × CM	0.93				
	M. incognita population at transplanting (Eggs and J2/cm^3 soil)				
0	7.1	4.5	3.0	2.9	4.4
1.0	2.6	2.5	2.1	2.9	2.5
2.0	3.4	3.5	1.5	3.4	2.9
4.0	2.7	2.1	3.0	3.2	2.7
Mean	3.9	3.1	2.4	3.1	—
0 + Fenamiphos	4.5	—	—	—	
ANOVA F values:					
OP rate	1.47 **				
CM rate	4.84 **				
OP × CM	3.37 **				
	M. incognita population at harvest (Eggs and J2/cm^3 soil)				
0	20.4	10.7	9.7	7.1	12.0
1.0	10.1	9.8	7.7	6.3	8.5
2.0	8.8	8.4	6.0	6.1	7.3
4.0	7.1	8.7	8.1	3.6	6.9
Mean	11.6	9.4	7.9	5.8	—
0 + Fenamiphos	8.5	—	—	—	—
ANOVA F values:					
OP rate	11.93 **				

* = F values significant at P = 0.05; ** = F values significant at P = 0.01.

Table 3. (Continued) Factorial analysis of the second year olive pomace (OP) and chicken manure (CM) amendments on cantaloupe (cv. Deloro) yield and *M. incognita* soil population.

	OP rate (t/ha)				
CM rate (t/ha)	0	25	50	100	Mean
CM rate	10.59 **				
OP × CM	3.37 **				

* = F values significant at P = 0.05; ** = F values significant at P = 0.01.

either alone or mixed with CM, and combined with other management practices, such as soil solarization (Gamliel and Stapleton, 1993), may enhance the above processes and in turn their nematicidal effect.

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