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The effect of soil compost treatments on potato cyst nematodes *Globodera rostochiensis* and *Globodera pallida*

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Summary

A pot experiment on potato was carried out to verify the nematicidal effect of four composts of different origin (C1: 70 % horse manure + 15 % sugar beet pomace + 5 % poultry manure + 10% grape pomace; C2: 100 % pig manure decomposed by juveniles of *Musca domestica*; C3: 100 % vermicompost from medical plants wastes; C4: 100 % vermicompost from cattle manure) on the potato cyst nematodes *G. rostochiensis* (Ro1) and *G. pallida* (Pa2 and Pa3). Composts at different rates (1.0, 2.5 and 5.0 % w/w) were mixed with the nematode infested soils. Pots with unamended soils were used as control. Pots (4 l) were arranged in a glasshouse according to a randomized block design with four replications per each treatment. A significant reduction in number of cysts, eggs and juveniles/cyst and eggs and juveniles/g soil was observed in each compost in comparison to unamended soil. The suppressive nematode effect increased according to the compost NH_4^+ content and compost rate.

Keywords: potato cyst nematode; *Globodera rostochiensis*; *Globodera pallida*; compost; soil organic amendments; pathotypes

Introduction

According to the recent European Legislations (Reg. CE 396/2005; 1095/2007; 33 and 299/2008 and 1107/2009) which have deeply restricted and revised the use of pesticides on agricultural crops, the increasing attention to the environment safety and to human and animal health is stimulating investigation to find new alternative control strategies that are environmentally sound and economically convenient at the same time. Therefore, research on low environmental impact alternatives to chemicals has received a strong impulse and considered a wide range of options including agronomic and physical methods (green manures, crop rotations, soil amendments, the use of resistant cultivars and arbuscular mycorrhyzal fungi, soil solarization and steam), the use of natural products from plants and biological control agents (Gamliel *et al.*, 2000; Vannacci & Gullino, 2000; Sasanelli *et al.*, 2002, 2008, 2009; D'Addabbo & Sasanelli, 2003; Nico *et al.*, 2004; Ogbenin, 2004; Atungwu, 2005; D'Addabbo *et al.*, 2005; Castillo *et al.*, 2006).

Among these alternative control strategies, the incorporation into the soil of organic amendments it is particularly interesting because of their low cost and a more general positive agronomic effect on plant growth and physical, chemical and biological properties of the soils (Davey, 1996). Moreover, it can allow the management of large amounts of wastes generated by urban settlements and agro-industrial processes, after their transformation by composting process, and in addition, it can improve plant resistance and plant protection by stimulating root development by recycling plant nutritive elements (De Bertoldi, 2008). Many organic material wastes represent an important resource of nitrogen, phosphorous, calcium and other elements as zinc, copper and magnesium essential to plant growth (Tester, 1990).

There are sufficient data to indicate that organic materials reduce disease incidence caused by a wide range of plant pests including bacteria, soil-borne pathogens and phytoparasitic nematodes species (D'Addabbo *et al.*, 1997; 2000; Abawi & Widmer, 2000; Bailey & Lazarovits, 2003; Renčo *et al.* 2007, 2009, 2010; Hu & Qi, 2010). In particular, the suppressive effect of soil amendments, with a wide range of composted waste materials, on plant parasitic nematodes was largely and frequently documented, although an inconsistent nematode control or variable effects were also described in literature (Szczech *et al.*, 1993; McSorley & Gallagher, 1995; McSorley *et al.*, 1997; Akhtar & Malik, 2000; Zhao *et al.*, 2003).

Therefore, the nematicidal effect of compost amendments is scarcely predictable as depending on the starting raw

Table 1. Chemical analysis of used composts

Compost	pH* (1:10) H_2O	DM (%)	N_t (mg/kg DM)	$N\text{-}NH_4^+$ (mg/kg DM)	C_L (mg/kg DM)	C:N
C1	8.4**	45.50	14,221	436	18,450	12.4:1
C2	7.9	87.83	24,465	1,260	16,890	16.2:1
C3	7.7	59.68	7,956	112	9,045	14.4:1
C4	7.0	69.00	17,731	168	27,000	9.2:1

DM - dry matter, N - total nitrogen, NH_4^+ - ammonium ions, C_L - available carbon;
*pH value in aqueous extract, which was obtained by mechanically shaking the samples for 1 hour with double distilled water at a solid: water ratio of 1:10 (dry weight x volume^{-1});
**Each value was an average of four replictions.

materials, the type of composting process, the maturity of the final product incorporated into the soil, nematode species present and season of application (Rodríguez-Kábana *et al.*, 1987; Rivera & Aballay, 2008). Many mechanisms can be involved in this suppressive effect such as decomposition of the compost into the soil and ammonia production, stimulation of soil microbial biomass and release of biocidal substances, which have nematicide activity (McSorley & Gallaher, 1996; Oka & Yermiyahu, 2002). The nematicidal activity, therefore, should be specifically assessed for each compost. The study presented in this paper was aimed to a comparative evaluation of the nematicidal potential of four new composts, based on horse, poultry, pig and cattle manures, sugar beet pomace, grapevine and medical plant wastes, largely available in Slovak Republic, against different pathotypes of the potato cyst nematodes *Globodera rostochiensis* (Woll.) Behrens (Ro1) and *G. pallida* (Stone) Behrens (Pa2 and Pa3) on potato (*Solanum tuberosum* L.). cv. Désirée in potting mixtures, in glasshouse condition.

Material and methods

Four different composts (C_1: 70 % horse manure + 15 % sugar beet pomace + 5 % poultry manure + 10 % grape pomace; C_2: 100 % pig manure decomposed by juveniles of *Musca domestica*; C_3: 100 % vermicompost from medical plants waste; C_4: 100 % vermicompost from cattle manure) were added and mixed with steam sterilised sandy-loamy soil (80 °C for 30 min) at rates of 1, 2.5 and 5 % w/w (dry weight). Each mixture was then used to fill plastic pots (20 cm diameter) with 4 000 g of soil. Pots with unamended soil were used as control. One month later, one hundred cysts of *G. rostochiensis*, previously identified as pathotype Ro1, and one hundred cysts of *G. pallida* of the pathotypes Pa2 and Pa 3 were added to each pot (including the control, and a potato tuber (cv. Désirée) was sown at the same time. All pots were arranged in a glasshouse at 20 ± 3 °C according to a randomized block design with 4 replications per treatment. During the experiment, potato plants were maintained in the glasshouse randomizing the position of the blocks and at

Table 2. The effect of four composts, at different doses, on the suppression of *Globodera rostochiensis,* pathotype Ro1

Compost	Compost rate % w/w	Number								
		Cysts			Egg and Juveniles/cyst			Egg and Juveniles/g soil		
C1	0	437*	a**	A	269	a	A	29.5	a	A
	1.0	286	b	B	211	b	B	15.2	b	BC
	2.5	261	cd	B	136	c	C	8.9	c	CD
	5.0	195	d	B	112	c	C	5.5	c	D
C2	0	437	a	A	269	a	A	29.5	a	A
	1.0	152	b	B	216	b	B	8.3	b	B
	2.5	114	b	BC	182	c	C	5.2	bc	BC
	5.0	44	c	C	122	d	D	1.3	c	C
C3	0	437	a	A	269	a	A	29.5	a	A
	1.0	410	a	A	240	b	A	24.6	a	AB
	2.5	365	b	A	203	c	B	18.4	b	BC
	5.0	352	b	A	179	c	B	15.5	b	C
C4	0	437	a	A	269	a	A	29.5	a	A
	1.0	326	b	B	212	b	B	17.3	b	B
	2.5	271	b	BC	202	b	BC	13.8	b	BC
	5.0	188	c	C	167	c	C	7.9	c	C

* Each value is an average of 4 replications; ** For each compost, data flanked in each column by the same letters are not statistically different according to Least Significant Difference Test (small letters for P = 0.05; capital letters for P = 0.01).

Table 3. The effect of four composts, at different doses, on the suppression of *Globodera pallida,* pathotype Pa2

Compost	Compost rate % w/w	Number								
		Cysts			Eggs and Juveniles/cyst			Eggs and Juveniles/g soil		
C1	0	386*	a**	A	348	a	A	35.3	a	A
	1.0	324	b	AB	275	b	B	22.3	b	B
	2.5	303	b	B	190	c	C	14.3	c	C
	5.0	295	b	B	132	d	C	9.7	c	C
C2	0	386	a	A	348	a	A	35.3	a	A
	1.0	203	b	B	248	b	B	12.0	b	B
	2.5	146	c	B	123	c	C	4.6	c	C
	5.0	79	d	C	97	d	C	2.4	c	C
C3	0	386	ab	A	348	a	A	35.3	a	A
	1.0	441	a	A	315	a	A	34.5	ab	A
	2.5	369	b	A	311	a	A	28.8	b	A
	5.0	263	c	B	229	b	B	15.4	c	B
C4	0	386	a	A	348	a	A	35.3	a	A
	1.0	266	b	B	254	b	B	17.1	b	B
	2.5	269	b	B	211	b	BC	14.3	b	B
	5.0	163	c	C	154	c	C	6.5	c	C

*Each value is an average of 4 replications; **For each compost, data flanked in each column by the same letters are not statistically different according to Least Significant Difference Test (small letters for P = 0.05; capital letters for P = 0.01).

the same time repositioning each plant within a block every week, to avoid a block position effect as well as the factor position of the potato plant within the block. The chemical analysis of the tested composts were performed from 10g of each compost (Table 1) according to STN 465 735 analysis method (1991). The pH value (1:10 water extract, using a pH electrode) and dry matter (DM - drying at 105 °C to a constant weight) were determined. Portions of samples for N_t determination were digested using the Didesdahl apparatus (Hach, Loveland, CO, U.S.A.). N_t was distilled with NaOH (40 %) (Bremner,1996). Water-soluble ammonium nitrogen (NH_4^+) was determined by titration (Mulvaney, 1996). The C content was calculated according to the content of organic matter (OM) by the method of Navarro *et al*., (1993). Also, the C:N ratio was calculated. After three months, a 500 g soil sample was collected from each pot and cysts were extracted by the flotation method (Sabová & Valocká, 1980) of infested soil

Table 4. The effect of four composts, at different doses, on suppression of *Globodera pallida,* pathotype Pa3

Compost	Compost rate % w/w	Number								
		Cysts			Eggs and Juveniles/cyst			Eggs and Juveniles/g soil		
C1	0	566*	a**	A	370	a	A	52.4	a	A
	1.0	464	b	AB	305	b	B	35.3	b	B
	2.5	373	b	BC	294	b	B	27.3	c	B
	5.0	272	c	C	214	c	C	14.5	d	C
C2	0	566	a	A	370	a	A	52.4	a	A
	1.0	168	b	B	164	b	B	6.8	b	B
	2.5	118	b	BC	115	c	C	3.3	b	B
	5.0	32	c	C	110	c	C	0.9	b	B
C3	0	566	a	A	370	a	A	52.4	a	A
	1.0	408	b	B	372	a	A	38.3	b	AB
	2.5	252	c	C	356	a	A	36.0	b	B
	5.0	162	d	C	286	b	B	21.0	c	C
C4	0	566	a	A	370	a	A	52.4	a	A
	1.0	408	b	B	305	b	B	31.6	b	B
	2.5	252	c	C	225	c	BC	14.3	c	C
	5.0	214	c	C	356	a	C	13.8	c	C

*Each value is an average of 4 replications; **For each compost, data flanked in each column by the same letters are not statistically different according to Least Significant Difference Test (small letters for P=0.05; capital letters for P=0.01).

Table 5. General comparison among compost rates on different pathotypes of the Potato Cyst Nematodes (PCN) *G. rostochiensis* and *G. pallida*

Nematode/ pathotype	Compost rate % w/w	Number								
		Cysts			Eggs and Juveniles/cyst			Eggs and Juveniles/g soil		
***Globodera rostochiensis* Ro1**	0	437*	a**	A	267	a	A	29.5	a	A
	1.0	293	b	B	220	b	B	16.3	b	B
	2.5	252	bc	BC	181	c	C	11.6	c	BC
	5.0	195	c	C	145	d	D	7.5	d	C
***Globodera pallida* Pa2**	0	386	a	A	348	a	A	32.8	a	A
	1.0	308	b	AB	273	b	B	21.5	b	B
	2.5	271	b	BC	209	c	C	15.5	c	BC
	5.0	200	c	C	153	d	D	8.5	d	C
***Globodera pallida* Pa3**	0	566	a	A	370	a	A	52.4	a	A
	1.0	363	b	B	293	b	B	27.9	b	B
	2.5	248	c	C	247	bc	BC	20.2	bc	BC
	5.0	170	d	C	217	c	C	12.6	c	C

*Each value is an average of 4 replications; **For the same pathotype, data flanked in each column by the same letters are not statistically different according to Least Significant Difference Test (small letters for P = 0.05; capital letters for P = 0.01).

of each pot. The extracted cysts were crushed, and the number of viable eggs and second-stage juveniles (J_2) were counted. Data were statistically analysed by the factorial analysis of variance (ANOVA) and means compared by the Least Significant Difference Test at P = 0.05 and 0.01. Statistical analyses were performed using the PlotIT program. TableCurve program was used to analyze the relationships between different compost doses and nematological parameters of potato cysts nematodes.

Results

Chemical analysis of composts

Results from chemical analysis of the four composts are reported in Table 1. The value of pH was neutral (7.00) only in C4 compost. In all other composts, it was lightly alkaline, and it ranged between 7.7 and 8.4. The lowest percentage of dry matter (DM) was observed in the C1 compost based on horse manure with the addition of different percentages of poultry manure, sugar beet and grape pomace. The highest DM percentage was found in C2 compost based on *Musca domestica* decomposed pig manure. In C3 and C4, DM percentages were 59.68 and 69.00, respectively. The compost C2 contained the highest level of the total nitrogen (N_t) (24,465 mg/Kg DM), followed by the C4 compost. The lowest N_t content was observed in C3 compost. The content of NH_4^+ was highest in C2 compost according to the highest Nt level observed in the same compost. In C3 and C4 composts, the NH_4^+ contents were about 9 and 13 times lower than that observed in C2 compost, respectively. The highest available carbon content was recorded in C4 compost (27,000 mg/Kg DM) at which corresponded the lowest C:N ratio (9.2:1) (Table 1).

Table 6. General comparison among composts and their effects on different pathotypes of the Potato Cyst Nematodes (PCN) *G. rostochiensis* and *G. pallida*

Nematode/ pathotype	Compost	Number								
		Cysts			Eggs and Juveniles/cyst			Eggs and Juveniles/g soil		
***Globodera rostochiensis* Ro1**	C_1	295*	b**	B	182	a	A	14.7	a	AB
	C_2	187	a	A	197	ab	A	12.9	a	B
	C_3	390	c	B	223	b	A	22.0	b	A
	C_4	306	b	B	213	ab	A	17.1	ab	AB
***Globodera pallida* Pa2**	C_1	327	bc	BC	236	a	AB	19.8	a	AB
	C_2	203	a	A	204	a	A	12.9	a	A
	C_3	365	c	C	301	b	B	27.8	b	B
	C_4	272	b	AB	242	ab	AB	17.6	a	AB
***Globodera pallida* Pa3**	C_1	419	a	A	295	a	A	32.4	a	A
	C_2	221	b	B	189	b	B	15.8	b	B
	C_3	347	a	A	346	a	A	36.9	a	A
	C_4	360	a	A	295	a	A	27.8	a	AB

*Each value is an average of 4 replications; **For the same pathotype, data flanked in each column by the same letters are not statistically different according to Least Significant Difference Test (small letters for P=0.05; capital letters for P=0.01).

Table 7. Relationship between ammoniacal content (NH_4^+) in the different composts and number of cysts, eggs and juveniles/cyst and eggs and juveniles/g soil of different pathotypes of potato cyst nematodes (PCN)

Nematological parameter	PCN and pathotype	Equation	*r*
N° cysts	*G. rostochiensis* Ro1	$y = 508.82 - 30.94 * x^{0.326}$	- 0.944
	G. pallida Pa2	$y = 327.02 - 8.566e\text{-}05 * x^{1.986}$	- 0.834
	G. pallida Pa3	$y = 376.37 - 3.706e\text{-}09 * x^{3.425}$	- 0.917
N° eggs and J2/cyst	*G. rostochiensis* Ro1	$y = 189.76 + 108.41^{(-x/98.71)}$	- 0.920
	G. pallida Pa2	$y = 213.83 + 1{,}054{,}869.7/x^2$	- 0.950
	G. pallida Pa3	$y = 342.81 – 0.171 * x^{0.951}$	- 0.959
N° eggs and J2/g soil	*G. rostochiensis* Ro1	$y = 13.43 + 104{,}376.23/x^2$	- 0.990
	G. pallida Pa2	$y = 15.04 + 148079.45/x^2$	- 0.866
	G. pallida Pa3	$y = 32.61 – 8.398e\text{-}09 * x^3$	- 0.912

Suppression of the cyst nematode populations G. rostochiensis and *G. pallida.*

The four compost significantly reduced the final soil cyst nematode *G. rostochiensis* population, pathotype Ro1, in comparison to untreated soil (control - 0 dose), even at the lowest amendment rate (1 %) irrespective of the compost origin (Table 2) with the exception of dose at 1 % of compost C3 for the number of cysts and eggs and juveniles/g soil (Table 2).

The lowest effective control of the cyst nematode population *G. rostochiensis* (Ro1) was observed in the compost C3 ($P = 0.05$). No statistical differences were observed in number of cysts among the different C3 compost rates at 0.01 level ($P = 0.01$), including the untreated control. This non effective control could be attributed the lowest value of NH_4^+ contents recorded in the chemical analysis of compost C3 (Table 1 – 2). The highest significantly cyst nematode reduction (N° of cysts, eggs and juveniles/cyst and eggs and juveniles/g soil) was observed at the highest rate of each compost (5 %) (Table 2).

The effects of the different rates of the four composts on *G. pallida*, pathotype Pa2 and Pa3, are reported in Table 3 and 4, respectively.

The number of *G. pallida* (Pa2) cysts, eggs and juveniles per cyst and per g soil was significantly already reduced at the lowest amendment dose (1 %) of C1, C2 and C4 composts ($P = 0.05$). In the compost C3, with the lowest NH_4^+ content, only the highest dose (5 % w/w) was effective to reduce the number of cysts, eggs and juveniles per cyst and per g soil ($P = 0.01$) (Table 3). The number of cysts and eggs and juveniles per g soil of the pathotype Pa3 of *G. pallida* was significantly reduced by all doses of compost C3 (Table 4) in contrast with the previous results obtained with same compost for *G. rostochiensis* (Ro1) and *G. pallida* (Pa2). Only the number of *G. pallida* (Pa3) eggs and juveniles per cyst was not reduced amending the soil with C3 compost with the exception of the highest dose (Table 4). In general, the highest significative reductions of all nematological parameters for *G. rostochiensis* (Ro1) and *G. pallida* (Pa2 and Pa3), in almost all composts, were obtained with 5 % (w/w) soil amendment rate, independently from the type compost.

General comparison among compost rates

In each soil amended with the four composts, a significant reduction of the number of cysts in 400 g soil samples, eggs and juveniles per cyst and per g soil was observed in comparison with unamended soil (control at 0 % dose) for all the different considered pathotypes of *G. rostochiensis* (Ro1) and *G. pallida* (Pa2 and Pa3), even at the lowest amendment rate (1 % w/w) irrespective of the compost origin (Table 5). These results confirm the reduced nematode reproduction in the compost treated soil, and they highlighted that number of cysts, eggs and juveniles per cyst and per g amended soil decreased linearly as compost rate soil addition increased (Table 5).

General comparison among composts

G. rostochiensis (Ro1) females were significantly suppressed only by the compost C2 in comparison to the other composts which were not statistically different from each other ($P = 0.01$) (Table 6). Also, the numbers of eggs and juveniles per g soil were significantly lower in soil amended with the compost C2 compared to compost C3 and no evident and significant differences were found among C2 and C1 and C4 compost, although these two latter composts were not significantly different from C3 ($P = 0.01$) (Table 6). The number of eggs and juveniles per cyst was not influenced by the different tested composts ($P = 0.01$) (Table 6).

For *G. pallida* (Pa2), a significant reduction in the cysts number was observed in soil treated with the compost C2 ($P = 0.05$) in comparison to all other composts (Table 6). A significant difference in number of eggs and juveniles per cyst and per g soil was found only between the lowest and highest value observed in soil amended with compost C2 and C3, respectively.

The highest and significant reduction of the number of cysts, eggs and juveniles per cyst and per g soil was observed in C2 compost treated soil in comparison to all other compost amended soils ($P = 0.05$) (Table 6).

Relationship between different doses of C1, C2, C3 and C4 composts and nematological parameters.

Based on the results, significant negative correlations were found in the relationship between the different applied

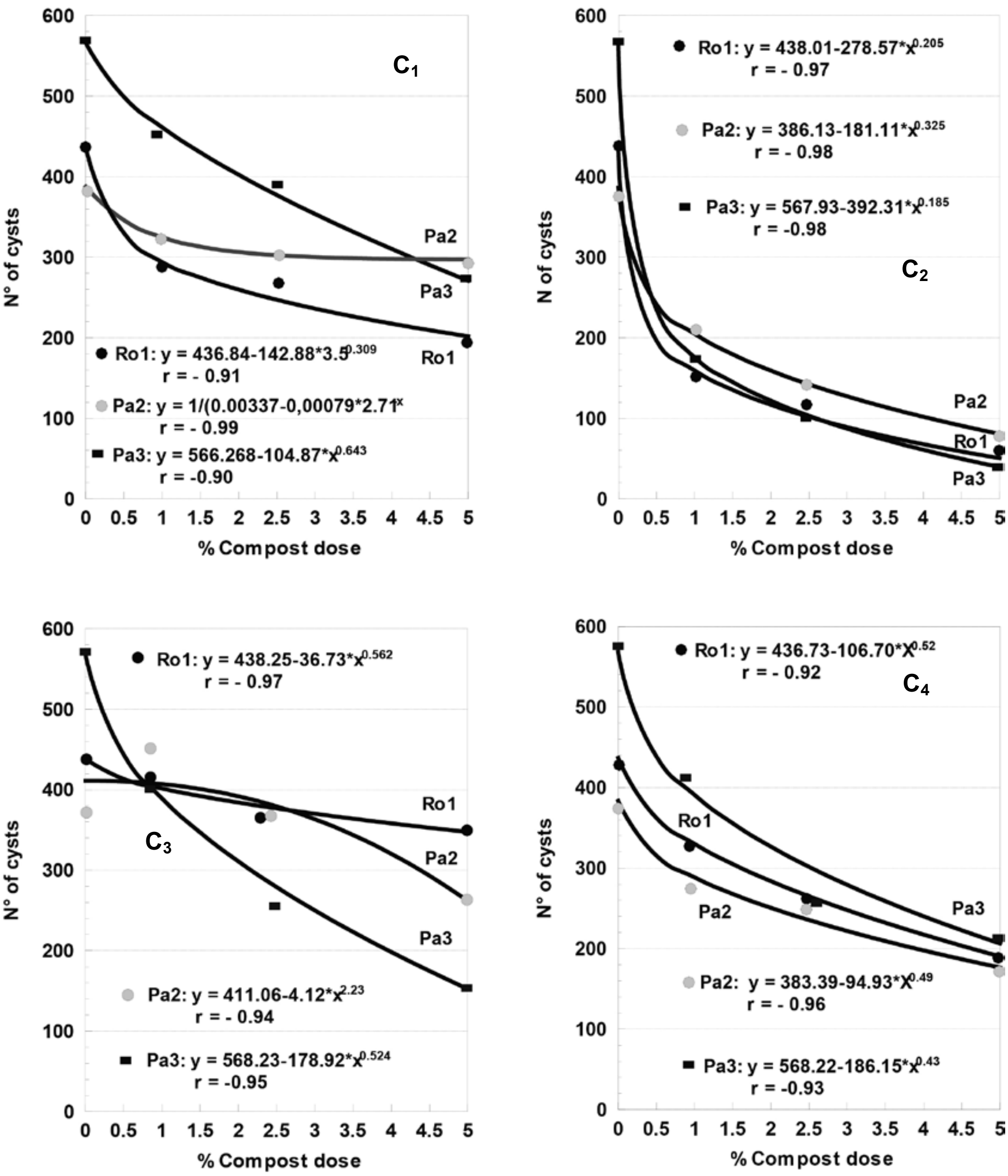

Fig 1. Relationships between different doses of C_1, C_2, C_3 and C_4 composts on number of cysts of *Globodera rostochiensis* (pathotype Ro1) and *G. pallida* (pathotypes Pa2 and Pa3)

doses of C1, C2, C3 and C4 composts and the values of the number of cysts (Fig. 1), eggs and juveniles/cysts (Fig. 2) and eggs and juveniles/g soil (Fig. 3) of *G. rostochiensis* Ro1, *G. pallida* Pa2 and Pa3. The equations reasonably explain the above relationships, as indicated by the high values of the correlation coefficients (*r*).

Also, the relationships of compost NH_4^+ content and the number of cysts, eggs and juveniles/cyst and per g soil were analysed. All these nematological parameters were significantly and negatively correlated with the NH_4^+ content of composts with the exception of *G. pallida* Pa2 for the number of cysts and eggs and juveniles/g soil (Table 7).

Discussion and Conclusions

Survival and reproduction rates of the PCN *G. rostochiensis* (Ro1) and *G. pallida* (Pa2 and Pa3) deriving from the four tested composts incorporated into the soil at four different rates were analysed and compared with each other. The compost C1, C2 and C4 were more effective to reduce the cysts number of the pathotypes Ro1 and Pa2 of PCN in comparison to C3 compost, irrespective to the compost dose. These findings agree with those deriving from *G. rostochiensis* (Ro1) with other composts of different origin applied at the same rates (0, 1, 2.5 and 5 %) to

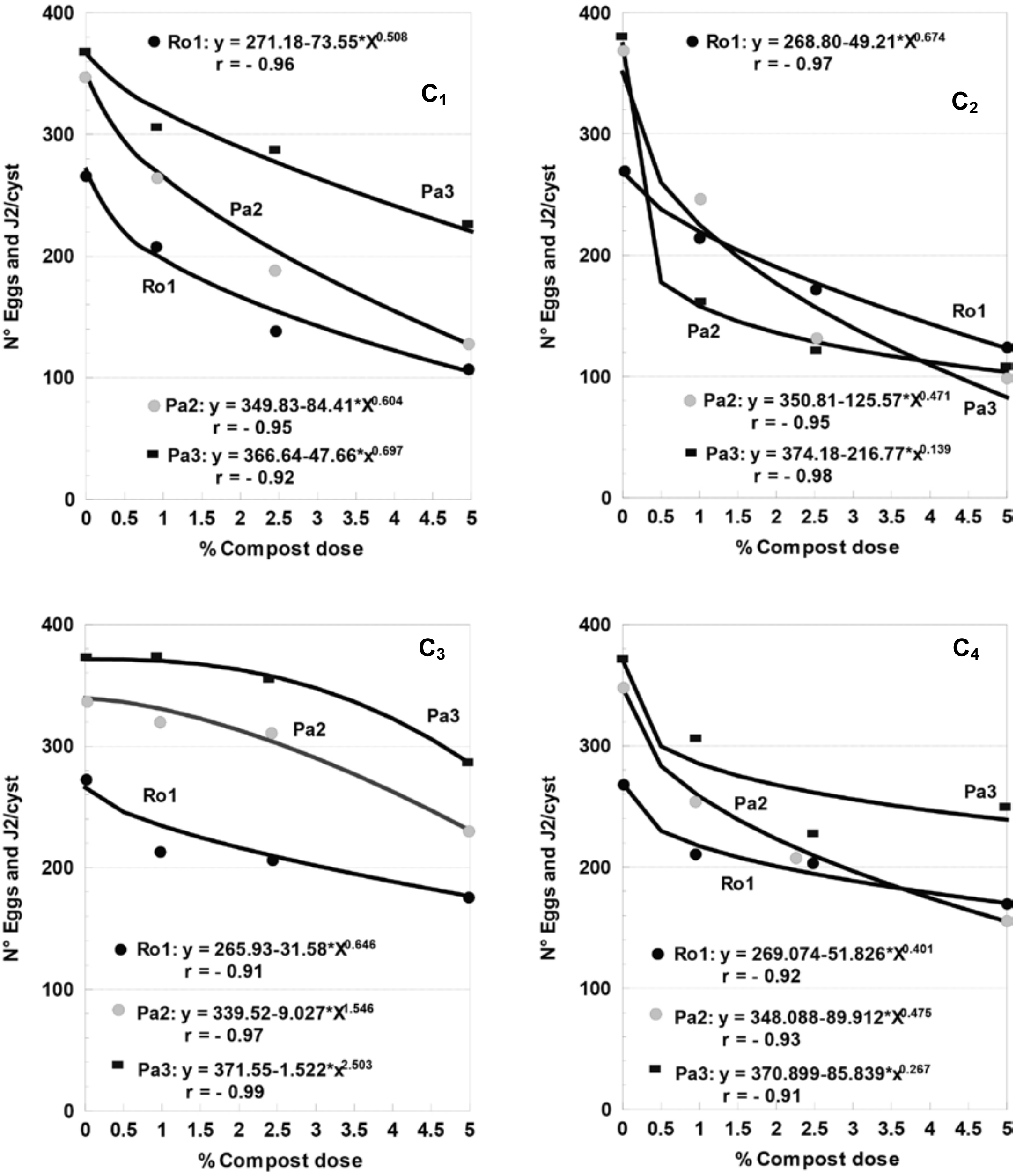

Fig 2. Relationships between different doses of C_1, C_2, C_3 and C_4 composts on eggs and J_2/cyst of *Globodera rostochiensis* (pathotype Ro1) and *G. pallida* (pathotypes Pa2 and Pa3

the soil (Renčo *et al*., 2007). A similar strong reduction of *Heterodera schachtii* population was observed in infested soils amended with compost (Schlang, 1993), although a vermicompost derived from cattle manure showed no inhibitory effect on the same plant parasitic nematode (Szczech *et al*., 1993). Results from our experiment are partially in agreement with those reported by Szczech (1993) because of no statistical differences were observed between the compost C4 (vermicompost based on cattle manure) and the lowest effective compost C3 in the reduction of the number of cysts, eggs and juveniles per cyst and per g soil, at a different level of probability, with the exception of the number of *G. pallida* Pa2 cysts. Some vermicomposts, similar to that used in our experiment confirm no nematicidal effect on the cyst nematode *Heterodera trifolii* (Kimpiski *et al*., 2003). On the contrary, a vermicompost was effective in the control of *Pratylenchus coffeae* and *Helicotylenchus multicinctus*, which are no cyst nematodes (Sundararaju *et al*., 2002). In soil infested by sedentary endoparasite *Rotylenchulus reniformis* a significant nematode reduction was observed adding different doses of biofertilizers and olive pomace based compost into the soil, with a significantly positive correlation between applied doses of compost treatments and reduction of nematode populations (Ismail *et al*., 2006).

Probably, the cyst nematodes are more resistant than endoparasitic, ectoparasitic and sedentary ectoparasitic nema-

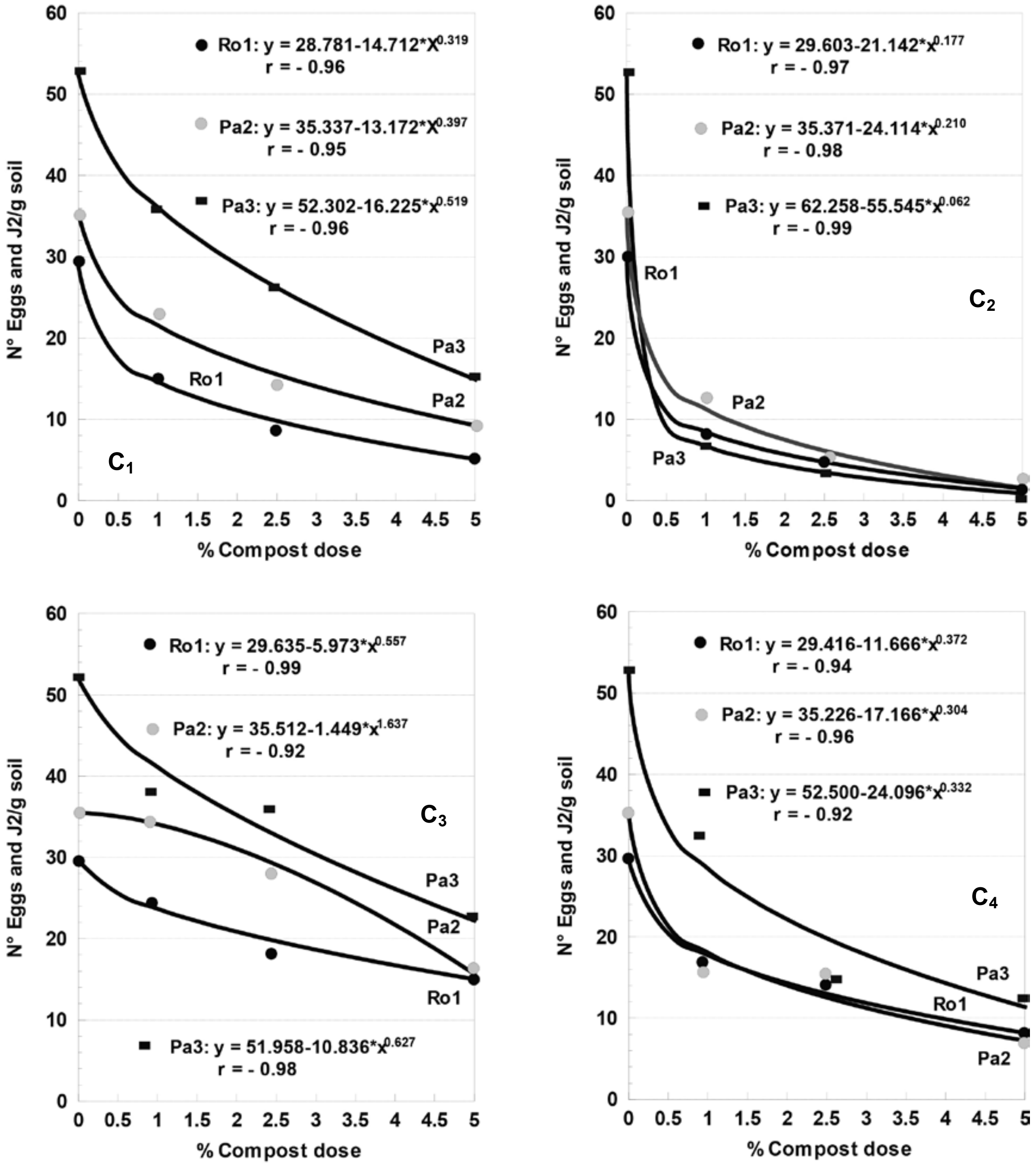

Fig 3. Relationships between different doses of C_1, C_2, C_3 and C_4 composts on eggs and J_2/g soil of *Globodera rostochiensis* (pathotype Ro1) and *G. pallida* (pathotypes Pa2 and Pa3)

todes because of the presence of the layer of dead cuticle of females, which serves to protect the eggs, and second-stage juveniles that are retained within (Zunke & Eisenback, 1998). In addition, the lower nematicidal effect of compost C3 and C4 can be reasonably explained also by the lowest NH_4^+ content (112 and 168 mg/kg DM, respectively) (Table 1).

The nematicidal activity of the different organic amendments is also influenced by the C:N ratio, amount of amendment used and on the decomposition time (Akhtar & Malik, 2000). The use of nitrogen by plants due to the microbial decomposition is also dependent by C:N ratio. A C:N ratio, in organic matter, greater than 20:1, temporarily can immobilised N in microbial tissues creating an N-deficient uptake in plants. On the contrary, in residues or wastes with a C:N ratio less than 20:1, N can be mineralised in NH_4^+ or NO_3^- for absorption by plant root systems. The availability of more N enhances the nematicidal activity against plant parasitic nematodes of the organic amendments, as also reported by Mian & Rodriguez-Kábana (1982). Sometimes the incorporation of organic matter into the soil can create phytotoxic problem. The addition of nitrogen sources to fresh organic matter may increase the nematicidal effect, enabling it to be used at lower dosages and thus reducing phytotoxicity (Rodriguez-Kábana *et al*., 1992; 1995; Sasanelli *et al*., 2006).

The most effective compost in the control of both PCN *G. rostochiensis* and *G. pallida* was the compost C2. In particular, this compost showed a significant nematicide effect especially on the pathotype Pa3 in comparison to all other composts (Table 6). This highest nematicidal activity could be explained by the highest DM (87.8 % - Table 1) and NH_4^+ content observed in the compost C2 (1,260 mg/Kg DM - Table 1). Moreover, in previous studies the same compost was found to improve significantly yield of broccoli and sunflower (Kováčik *et al*., 2008; 2010).

In conclusion, data from our experiment confirm that the use of composts may present a valuable possibility for an eco-compatible management of the PCN *G. rostochiensis* (Ro1) and *G. pallida* (Pa2 and Pa3), especially if amendment soils are applied for consecutive years, as it was previously demonstrated on root-knot nematodes (D'Addabbo *et al*., 2003).

In particular, the compost C2, based on pig manure transformed by larvae of house flies, had a positive effect on soil organic matter improving soil quality and fertility and plant tolerance to nematode attack (McSorley & Gallagher, 1995; Everts *et al*., 2006). The marked suppressive effect on reproduction of females, number of eggs and juveniles per cyst and per g of soil, was showed even at the lowest rate of compost addition (1 %) confirming its importance for field application in PCN control. However, the positive results observed in composts with different origin and composition suggests that the formulation of compost must be based on locally available wastes in order to provide composts at low cost without reducing their technical validity, especially in nematicidal efficacy.

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