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EFFECTIVENESS OF PLANT-DERIVED FORMULATIONS AGAINST THE ROOT-KNOT NEMATODE *MELOIDOGYNE INCOGNITA* (KOFOID *ET* WHITE) CHITW. IN A PROTECTED TOMATO CROP.

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d'Errico G., Giacometti R., Soppelsa O., D'Alessio M. – Effectiveness of plant-derived formulations against the root-knot nematode *Meloidogyne incognita* (Kofoid *et* White) Chitw. in a protected tomato crop.

The effectiveness of two plant-derived formulations for the control of the root-knot *Meloidogyne incognita* (Kofoid *et* White) Chitw. was evaluated in a protected tomato crop in Southern Italy. A neem oil-based formulation and a commercial mixture of aqueous extracts of *Quillaja saponaria* Molina (80%), *Yucca schidigera* Roezl (10%) and *Tagetes* spp. (10%) were tested in comparison with the standard chemical oxamyl and an untreated control. All tested formulations significantly decreased soil nematode population and average root galling compared to the untreated control. However, nematode infestation was found significantly lower in plots treated with oxamyl or neem formulation than in those treated with quillay-based product. Tomato yield did not significantly differ among treatments. Satisfactory yield obtained by quillay-based product appears to be caused by the biostimulating effect of quillay extract on tomato plants.

KEY WORDS**:** plant-derived formulations, *Meloidogyne incognita*, tomato, control.

INTRODUCTION

Ban of fumigant 1,3-dichloropropene (1,3-D), the only one with primary nematicidal activity, and of most nematicides available on the market, is increasing the need of new nematode control tools (LAMBERTI and D'ADDABBO, 2003). Within this context, natural bioactive compounds derived from plants are being explored as potential alternatives to conventional nematicides, mainly as they are not suffering competition by soil biotic components such as nematode-antagonist micro-organisms (CHITWOOD, 2002).

Azadirachtin is the main active component of neem (*Azadiracta indica* A. Juss) oil and its formulations have been gradually imposed on the agrochemical market for nematode management strategies in greenhouse crops and in organic or integrated and minimal processed systems (D'ERRICO *et al*., 2003; COLOMBO *et al*., 2005; D'ADDABBO *et al*., 2008*a*, 2008*b*).

Nematicidal activity of aqueous extracts from the bark of another tree, i.e. quillay (*Quillaja saponaria* Molina), is also reported by several field studies (D'ADDABBO *et al*., 2005; CURTO *et al*., 2007; D'ADDABBO *et al*., 2008*a*). These nematicidal properties are mainly derived by the high content of triterpenoids saponins (MEHER *et al*., 1988; OMAR *et al*., 1994). However, also polyphenols and tannins, present at consistent amounts in quillay extracts may be involved for their demonstrated toxicity to plant parasitic nematodes (MIAN and RODRIGUEZ-KABANA, 1982; HEWLETT *et al*., 1997; MAISTRELLO *et al*., 2010).

A recent commercial formulation, based on a mixture of aqueous extracts of quillay (80%), *Yucca schidigera* Roezl (10%) and *Tagetes* spp. (10%), showed to be effective against plant parasitic nematodes in laboratory tests (GIACOMETTI *et al*., 2010). Presence of different active ingredients, which would avoid the establishment of nematode resistance, is an additional valuable aspect of this formulation (FENG and ISMAN, 1995).

Nematicidal effectiveness of this quillay-based formulation was evaluated in comparison with a commercial azadirachtin formulation and the chemical nematicide oxamyl, for the control of the root-knot nematode *Meloidogyne incognita* (Kofoid *et* White) Chitw. in a greenhouse experiment on tomato [*Lycopersicon lycopersicum* (L.) Karsten ex Farw].

MATERIALS AND METHODS

The trial was undertaken in 2009 in an unheated 346 m^2 (14.4x24 m) polyethylene-house located at Battipaglia (province of Salerno), Southern Italy. Soil was medium textured tending to clay, slightly alkaline (pH 7.6) and heavily and uniformly infested by *M. incognita*. On April 11th 2009, soil was ploughed and divided into sixteen 25.2 m^2 (3.6 x 7 m) plots, arranged in a randomized block design with four replications per each treatment. Treatments in comparison were: 1) liquid oxamyl (10% a.i.) at the rate of 50 L ha^{-1}, splitted in five 10 L ha^{-1} applications in acidified water (pH 5.5), at transplanting (13th April) and at 15 days intervals; 2) azadirachtin formulation (2.5% a.i.) at 15 L ha^{-1}, splitted in five 3 L ha^{-1}

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treatments in acidified water applied as above; 3) quillay-based formulation at 45 L ha^{-1}, splitted in two 30 and 15 L ha^{-1} applications in water (pH = 6.9), at transplanting and 43 days after, respectively; 4) untreated soil. The three formulations were applied through a drip tape with at 35 cm intervals self-blocking and self-compensating drippers at a 2 L h^{-1} flow rate. Drip tape, laying along each plot and parallel to irrigation system, was closed by a cap at an extremity whereas the opposite extremity was connected to a pump injecting treatment solutions.

On April 13th 2009, tomato (cv. Incas) seedlings, previously raised in polystyrene poly-pots, were transplanted in rows 1.20 m apart, 40 cm along the row, at a density of 21,000 plants ha^{-1}. Drip irrigation, fertilization and disease and pests control treatments were applied according to agricultural practices common for the area.

Tomato was harvested at five different times (June 21st, July 16th, August 13th, September 10th and October 12th), and yield per plant was recorded at each time.

Nematode population density was assessed at transplanting date and before the last harvest (October 12th 2009). Nine small soil samples were collected from each plot and mixed in an unique bulk soil sample. Nematode migratory stages (second stage juveniles and males) were then extracted from a 10 cm^3 soil sub-sample by the direct cotton-wool filter method (OOSTENBRINK, 1960).

At the last harvest, ten tomato plants were randomly uprooted from the central sector of the middle row of each plot and average root galling index (AGI) was determined on a 0-5 scale (0 = no galls and 5 = root system completely deformed by large and numerous galls) (LAMBERTI, 1971), rating each treatment according to the following formula:

$$AGI = \frac{\sum \text{root galling score of the sampled plants}}{\text{Number of sampled plants}}$$

Data were processed by analysis of variance (ANOVA) and means compared by the Student-Newman-Keuls test at $P = 0.05$.

RESULTS AND DISCUSSION

Initial soil population density of *M. incognita* was high and uniform (Table 1). All treatments significantly decreased nematode population in the soil and the average root galling compared to untreated control. The lowest nematode population density and root gall index were found in the plots treated with oxamyl, though not significantly different from that ones obtained in soil treated with the azadirachtin formulation. Root gall index in plots treated with the azadirachtin formulation was also significantly lower than in plots treated with the quillay-derived formulation (Table 1). However, further research is needed to verify if the higher nematode suppression caused by oxamyl and azadirachtin formulation are caused by their higher nematicidal activity or to an incorrect quillay formulation application, which could require a more appropriate modulation of application dosages and times, as well as water pH.

All treatments significantly increased the tomato yield compared to untreated control (Table 2). In soil treated with azadirachtin and quillay formulations and oxamyl, yield was 29.1, 34.5 and 38.1 % higher than in untreated plots, respectively. Yield from plots treated with two plant formulations was not significantly different, whereas the treatment with oxamyl resulted in a yield significantly higher than the azadirachtin formulation. Effect of treatments on tomato yield was evident from the second harvest, whereas no differences emerged among treated and untreated plots at the first harvest, mainly due to the severe damage caused in the untreated plots by following nematode generations. Yield increases in the treated plots may be mainly due to the improved efficiency of tomato root system following nematode suppression by treatments. In previous studies, tomato yield increases provided by a quillay formulation ranged between those ones given by a neem product and oxamyl, as a result of a plant biostimulation effect of quillay extracts (D'ADDABBO *et al.*, 2005; CURTO *et al.*, 2007; D'ADDABBO *et al.*, 2008*a*).

Table 1. – Effects of the treatments on population density and root gall index of *Meloidogyne incognita*.

Treatments	Nematode population density (juveniles and males 10 cm^{-3} soil)		Root gall index
	13th April 2009	12th October 2009	
Oxamyl	19 a	876 a	2.7 a
Azadiractin formulation	16 a	983 a b	3.0 a
Quillay formulation	21 a	1.097 b	3.6 b
Untreated control	17 a	2.936 c	4.1 c

Means with same letter in the same column are not significantly different based on the Student-Newman-Keuls test at $P = 0.05$.

Table 2 – Effect of different treatments on average tomato yield per plant at each harvest, total yield and percent increment (Δ%) over untreated control.

Treatments	Yield at each harvest (Kg/plant)					Total (Kg/plant)	Δ%
	21/06	16/07	13/08	10/09	12/10		
Oxamyl	0.72 a	1.32 a	2.74 a	1.83 a	0.99 a	7.6 a	38.1 a
Azadiractin formulation	0.65 a	1.11 a b	2.41 a b	1.79 a	1.14 a	7.1 b	29.1 b
Quillay formulation	0.68 a	1.28 a	2.83 a	1.53 a b	1.08 a	7.4 a b	34.5 a b
Untreated control	0.64 a	0.98 b	2.07 b	1.32 b	0.49 b	5.5 c	–

Means with same letter in the same column are not significantly different based on the Student-Newman-Keuls test at $P = 0.05$.

Results from this study confirm that crop protection is essential in the presence of high initial population densities of root-knot nematodes. Application of tested formulations for root-knot nematode management may be also economically and environmentally beneficial in tomato crop for their side effects on other pests by avoiding some other treatments. Application of these formulations, especially the plant-derived ones, can be very useful in organic farming, where few nematode control tools are available; but they could be also extended to integrated management systems.

RIASSUNTO

EFFICACIA DI SOSTANZE DI ORIGINE VEGETALE PER IL CONTENIMENTO DEL NEMATODE GALLIGENO MELOIDOGYNE INCOGNITA *(KOFOID* ET *WHITE) CHITW. SU POMODORO*

L'efficacia di due differenti formulati di origine vegetale nel controllo del nematode galligeno *Meloidogyne incognita* (Kofoid *et* White) Chitw. è stata verificata comparativamente in una prova sperimentale su pomodoro in serra. Un formulato a base di azadiractina, estratto da *Azadiracta indica* A. Juss, ed uno basato su una miscela di estratti acquosi di *Quillaja saponaria* Molina (80%) *Yucca schidigera* Roezl (10%) e *Tagetes* spp. (10%), sono stati messi a confronto con una formulazione liquida del nematocida oxamyl e con un testimone non trattato. I risultati hanno evidenziato una riduzione delle densità di popolazione del nematode e della formazione di galle sulle radici significativamente maggiore nelle tesi trattate con oxamyl e azadiractina rispetto al testimone non trattato ed al formulato a base di quillaja. Tale formulato ha però fornito produzioni statisticamente non inferiori a quelle degli altri trattamenti, grazie all'attività di biostimolazione dello stato vegetativo delle piante svolta dall'estratto di quillaja.

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