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COMPARATIVE EFFICACY OF GARLIC CLOVE AND CASTOR SEED AQUEOUS EXTRACTS AGAINST THE ROOT-KNOT NEMATODE, *MELOIDOGYNE INCOGNITA* INFECTING TOMATO PLANTS

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Abstract: A greenhouse experiment using aqueous extracts of garlic (*Allium sativum*) cloves and castor bean (*Ricinus communis*) seeds, to control root-knot nematode, *Meloidogyne incognita* on tomato cv. Super strain B, was conducted. The plant materials were diluted with distilled water; the concentration was 10 g/100 ml. Four-week old tomato seedlings were planted in pots and arranged in a completely randomized block design for a treatment of five replicates. Approximately 2,000 juveniles of root knot nematode were pipetted around each plant. The botanical extracts were either soil drenched or foliar sprayed, for each pot. Cadusafos 10G (Rugby) as a nematicide, and non-treated pots served as the control. Results showed that tomato is susceptible to *M. incognita* infection. Botanical extracts were more effective and significantly ($p \leq 0.05$) reduced nematode criteria including number of galls and egg masses on roots of tomato and number of juveniles in roots and soil, compared to nematicide and non-treated plants. In general, a high dilution of the tested materials caused higher increases in lengths and weights of shoots and numbers and weights of fruits than those occurred by a low dilution.

Key words: *Allium sativum*, efficacy, *Lycopersicon esculentum, Meloidogyne incognita, Ricinus communis*

INTRODUCTION

Tomato (*Lycopersicon esculentum*) is an important and widely grown vegetable crop all over the world. Root-knot nematodes, *Meloidogyne* spp. are obligate parasites and very damaging plant pests limiting agricultural productivity. Most cultivated plant species are susceptible to root-knot nematode infection (Sasser and Carter 1985) reducing tomato yield by 30–50% (Saravanpriya and Sivakumar 2005). Some weeds in tomato farms should be regarded as an alternative hosts in the development of management systems for *Meloidogyne* spp. in tomato production (Gharabadiyan *et al.* 2012). Due to weeds presence before, during and after a crop cycle, weeds serve as reservoirs for plant pathogens and nematodes, some attempts were carried out to induce resistance in tomato plants against *Fusarium oxysporum* sp. *lycopersici* mediated through salicylic acid and *Trichoderma harzianum* (Ojha *et al*. 2012). Also, the impact of some biopesticide agents and microorganisms as azadirachtin, *Bucilsubtilis, Paecilomyces lilacinus* and oxamyl against *M. incognita* on the tomato plants (Khalil *et al.* 2012) was studied. In Egypt, root-knot nematodes, *Meloidogyne* spp., are becoming a real threat to almost all vegetable crops and they have been considered as limiting factors in crop production (Ibrahim 2011). The use of botanical extracts for controlling the root knot nematodes is becoming more and more appealing because of the growing problems of environmental pollution arising from the use of persistent pesticides. There has been a de-registration of some hazardous nematicides. Increasing pressure is on farmers to use non-chemical pest control methods that do not pollute the environment.

The efficacy of different plant extracts for use in nematode control has been studied. (Fatema and Ahmad 2005; Khan *et al*. 2011; Mousa *et al*. 2011). The nematicidal effect of garlic has been reported (Ali 1994; Ameen 1996; Amin and Youssef 1998; Osman *et al*. 2005; Algbenin *et al*. 2005; Bekhiet *et al*. 2010). Also, the effect of castor was studied (Youssef and Amin 1997; Katoll *et al*. 2010). Most of these studies focused on the tested materials used as soil treatment. Hence, the objective of this research is to compare the potentials of garlic clove and castor powdered seed aqueous extracts used as a soil drench or foliar spraying for the control of the root knot nematode, *M. incognita* infecting tomato.

MATERIALS AND METHODS

Plant material

Tomato, *Lycopersicon esculentum* (syn = *Solanum lycopersicon*) cv. Super train B seedlings.

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Preparation of aqueous extracts of garlic cloves and castor bean

Aqueous extracts of garlic (*Allium sativum*) cloves and castor bean (*Ricinus communis*) seeds were prepared by adding 10 g of each material to 100 ml distilled water, which were then left for 72 h before filtration through Whaman filter paper No. 1. Each extract was arbitrarily termed as a standard solution (S). Another dilution (S/2) was prepared by adding distilled water.

Root-knot nematode

Females and egg-masses of *M. incognita* were isolated from infested eggplant roots collected from the Giza region of Egypt. The culture of this nematode was established from single egg-masses of adult females previously identified by the morphological characteristics of the female perineal patterns (Taylor and Sasser 1978) and reared on eggplant cv. Pusa Purple Long plants in a greenhouse.

Greenhouse experiment

These materials with the above dilutions were added as a soil drench and foliar spraying as follows: Tomato cv. Super strain B of four-week-old seedlings were transplanted to pots 30-cm diam. containing 2 kg solarized sandy loam soil (1:1w/w). One week later, each pot was inoculated with 2,000 newly hatched second stage juveniles of the root-knot nematode obtained from pure culture. The previous materials were added twice; the first time was at the nematode inoculation in January, 2011, and the second time was one month later in February 2011. Also, the nematicide, rugby (cadusafos 10 G) at the rate of 0.02 g/pot (equivalent to 10 kg/feddan = 4,200 m^2) was tested as a comparison. There were five replicates for each treatment, and a similar number of pots with nematode only, served as the control. All the pots were arranged in a completely randomized block design and watered as needed. At the harvest stage, in May 2011, the plants were carefully uprooted. Soil was extracted using the sieving and decanting method. The number of galls and egg masses on the tomato roots were counted. An aliquot of 1 g of roots for each treatment were incubated according to Young (1954). The total number of juveniles in the soil and the total number of whole roots were recorded. The length and weight of the shoots and the number and weight of the fruits were also recorded.

Statistical analysis

The statistical analysis system (SAS 1999) analyzed the data by using the general linear model (GLM) procedure. Differences among groups were determined by Duncan's Multiple Range Test.

RESULTS

Effect on nematode parameters

Data in table 1 indicate nematode criteria of root knot nematode, *M. incognita* infecting tomato, as affected by different treatments of garlic clove and castor bean seed aqueous extracts. It was noticed that garlic clove extract as soil drench or foliar spraying treatments at both high (S) and low (S/2) dilutions, significantly ($p \leq 0.05$) reduced the number of galls and egg masses on roots as well as on the number of juveniles in the soil and roots of tomato, compared to the untreated check. The percentage reductions were positively proportional to the tested dilution; the higher the concentration of the extract, the higher the percentage of nematode reduction. A high concentration of garlic as a soil drench achieved higher percentages of nematode reduction than those caused by high concentration of foliar spraying. In fact, it was the low concentration of foliar spraying which caused higher percentages of nematode reduction. The same trend was noticed in relation to castor bean extract, either as soil or foliar spraying treatments. Nematicie, cadusafos moderately affected nematode criteria compared to the untreated check. In general, garlic extract caused higher nematode reduction than those occurred by castor extract in most cases.

Table 1. Effect of garlic and castor bean aqueous extracts on root knot nematode, *M. incognita* infecting tomato cv. Super Strain B

Treatment	Galls	Reduction [%]	Egg masses	Reduction [%]	Total No. of juveniles/pot	Reduction [%]
Garlic cloves						
Soil drench						
S	224 b	70.4	109 d	74.2	563 cd	35.9
S/2	339 b	55.2	145 cd	42.7	1,319 a	–
Foliar spraying						
S	221 b	70.8	124 cd	70.6	392 d	55.4
S/2	274 b	63.8	172 cd	59.2	567 cd	35.4
Castor bean seeds						
Soil drench						
S	223 b	70.5	113 d	73.2	690 cd	21.4
S/2	654 a	13.5	342 b	19.0	742 bc	15.5
Foliar spraying						
S	352 b	58.7	186 cd	55.2	796 bc	9.3
S/2	335 b	55.7	199 cd	52.1	1,143 a	–
Cadusafos 10 G	390 b	48.4	209 cd	59.9	527 cd	33.0
The untreated check	756 a	–	422 a	–	878 b	–

Values are averages of 5 replicates; Figures in each column followed by different letter(s) are significantly ($p \leq 0.05$) different according to Duncan's Multiple Range Test; S – standard, S/2 – standard /2

Table 2. Tomato growth and fruit criteria as influenced by garlic and castor bean aqueous extracts for management of root knot nematode, *M. incognita*

Treatment	Shoot				Fruits			
	length [cm]	inc. [%]	weight [g]	inc. [%]	length [cm]	inc. [%]	weight [g]	inc. [%]
Garlic cloves								
Soil drench								
S	55.4 a	2.2	49.1 ab	4.5	3.0 b	114.3	106.02 a	192.1
S/2	58.8 a	8.5	48.1 ab	2.3	3.0 b	114.3	94.70 ab	160.9
Foliar spraying								
S	62.9 a	16.1	55.2 ab	7.4	4.8 a	242.9	76.00 abc	109.4
S/2	58.9 a	8.7	52.4 ab	1.5	2.4 bc	71.4	67.60 bcd	86.2
Castor bean seeds								
Soil drench								
S	58.7 a	8.3	48.1 ab	2.3	2.2 bc	57.1	52.90 cd	45.7
S/2	60.8 a	12.2	60.4 ab	2.4	2.2 bc	57.1	49.10 c	35.3
Foliar spraying								
S	67.8 a	25.1	57.2 ab	1.7	2.4 bc	71.4	62.10 cd	71.1
S/2	56.1 a	3.5	56.9 ab	1.1	2.2 bc	57.1	59.70 cd	64.5
Cadusafos 10 G	57.0 a	5.2	64.6 a	7.4	1.8 bc	28.6	43.80 cd	29.7
The untreated check	54.2 a	–	47.0 ab	–	1.4 c	–	36.30 d	–

Values are averages of 5 replicates

Figures in each column followed by different letter(s) are significantly ($p \leq 0.05$) different according to Duncan's Multiple Range Test; Inc. – increase; S – standard, S/2 – standard /2

Effect on tomato plant growth

As for tomato plant growth, the tested materials differed in their efficacy on plant growth parameters according to the method of treatment and concentration. In general, a high dilution of the tested material caused higher increases in the length and weight of shoots and the number and weight of fruits than those occurred by low dilution of the tested material. Garlic and castor bean as foliar spraying at high dilution, caused higher increases in the lengths and weights of plants than a high dilution as a soil drench. Fruit weight showed a regular trend as a high dilution of each extract achieved higher percentage fruit weight increases and vice versa. Cadusafos moderately affected the studied plant growth criteria and productivity. However, cadusafos achieved the highest weight of plants comparable to the other treatments and the untreated check.

DISCUSSION

In the present study, the nematicidal activity of the aqueous extracts of garlic cloves and castor seeds was evaluated against the root knot nematode *M. incognita,* infecting tomato. The tested materials reduced the number of galls and egg masses on tomato roots, and root and soil J_2 populations as compared to nematode-infected plants. Abd Elgawad *et al*. (2009) reported that soil treatment with a commercial product containing the aqueous garlic extract reduced the nematode-root gall index and increased the activity of catalase, B-1,3-glucanase, and enzyme of tomato leaves in comparison to nematode-infected plants. This trend continued in the roots, as an indicator of inducing resistance against the root knot nematode. In the present study, garlic extract showed no phytotoxicity in contrast to some earlier reports (Sukul *et al*. 1974), as they used 250 ml. of 50% garlic extract concentration per plant. This rate is nearly 12 times higher than the tested rate (20 ml of 10%) used in the present study. Such high concentrations may lead to osmotic loss of water from the root tissues resulting in wilting. On the other hand, Tibugari *et al*. (2012) reported that castor aqueous extract was > garlic aqueous extract > no treatment, regarding gall inhibition, 60 days after nematode inoculum by *M. javanica* on tomato. These results agree with those obtained by Ali (1994) and Osman *et al.* (2005) who attributed the nematode reduction to garlic cloves containing pyruvic acid, and ammonia together with diallyl disulphide. Also, Nigh (1985) mentioned that garlic possesses biochemical substances, and the allelopathic substances are toxic to nematodes. Ameen (1996) reported that the soil population of the reniform nematode, *Rotylenchulus reniformis* and *M. incognita* were significantly reduced in garlic monoculture or when garlic was intercropped with cowpea or tomato. She attributed the nematode reduction to garlic's contents of allelopathic substances or that garlic did not provide essential elements for nematode development. Following the same trend, Katoll *et al.* (2010) used an alcoholic extract of the leaf and seed of castor bean against *M. incognita* on cucumber which resulted in a reduced number of galls and a reduced population of nematode in soil, and caused the longitudinal growth of cucumber. From our study, it appears that with the use of the tested nematicide, the reduction percentages of nematode criteria were a representative indicator of the efficacy of cadusafos in reducing nematode infection on tomato, which is in agreement with previous studies (Queneherve *et al*. 1991; Reddy 2002).

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