Efficiency of jojoba oil and bio-nematicide on *Meloidogyne incognita* and performance of flame seedless grapevine cuttings

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Abstract: The whole world is moving to lay off chemical pesticides and replaced with natural compounds. Fortunately, jojoba oil is one of these alternatives, being a special type of plant oils containing many compounds that can improve growth, nutritional status of plants and tolerance to nematodes infection. The present study was conducted during the successive growing seasons 2015 and 2016, in the Pomology greenhouse, NRC, Dokki, Giza, Egypt. Flame Seedless grapevine cuttings (one year old) were selected to study the effect of jojoba oil at 5 and 10%, either with or without *Meloidogyne incognita* infection and Bio-Nematicide "Nema-Foo®" at 5 and 10%, with infection, was a comparison factor in addition to the control (uninfected and infected plants). These factors were investigated on cuttings' growth characters, nutrient contents and controlling the root-knot nematode. In general, the obtained results revealed that all treatments encouraged most of the investigated vegetative growth measurements and leaf nutrient contents. Meanwhile, they reduced *Meloidogyne incognita* numbers of juveniles (J_2) in soil. Moreover, J_2 galls and egg-masses were minimized in roots of grapevine cuttings as well as rate of build-up, comparing with the control (infected) plants, especially higher concentrations of these materials.

Keywords: flame seedless grapevine cutting, vigor growth, leaf nutrient content, *Meloidogyne incognita*

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1 Introduction

The grapevine (*Vitis vinifera* L.) is considered as one of the most economically fruit crops in the world. Flame Seedless is a promising grapevine cultivar that grown successfully under Egyptian environmental conditions and has progressively developed in the last few years. It is being cultivated in the newly reclaimed areas along the desert roads in North and Middle Egypt. Flame Seedless grapevine may be suffering under new reclaimed semi-arid areas from many factors which have a negative effect on growth, yield and fruit quality. Nematode spreading is one of these factors.

Root-knot nematode, *Meloidogyne* spp. has been recognized as a major limiting factor in agriculture production in many parts of the world. The use of nematicide to manage nematodes is being discouraged because of their polluting effects creating health hazards in human and animals. Numerous investigators have focused on non-chemical materials as bio-control agents against plant- parasitic nematodes. Using medicinal plants and essential plant oils such as jojoba oil (*Simmondsia chinensis* L.) has been found to suppress the population of certain phytonematodes, when grown with susceptible crops, using their extracts or products (El-Nagdi, 2005; El-Nagdi et al., 2009; Ismail et al., 2009 and 2011; Ahmed et al., 2012; Abdelmaksoud, 2014; and El-Saedy et al., 2015).

Jojoba oil is considered one of the most important of these materials, because it is completely different from the structure for all plant oils. It is chemically classify as a liquid wax output of union fatty acids and alcohol with a carbon chain and one long containing 40-44 carbon atoms, for this the areas use of very multi (Yermanos,

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1975). Moreover, jojoba oil is one of these alternatives to nematicide as it has the ability to eliminate mites and sucking insects' insightful, fungal diseases of the plant and nematode control (Mostafa et. al, 2017).

This study was planned to evaluate the efficacy of the jojoba oil and Nema-Foo® on performance of Flame Seedless grapevine cuttings and controlling *Meloidogyne incognita* under greenhouse conditions.

2 Materials and methods

2.1 Plant Material

Flame Seedless grapevine cutting was used in this study. Uniform cuttings similar in vigor, age (one year old) and size were transplanted in April to Pomology greenhouse, NRC, Dokki, Giza, Egypt. This study was conducted during two successive seasons (2015 and 2016) which started from mid-April to the end of October.

2.2 Soil Preparation

The soil contained peat moss + sand (1:2) ratio, treated with fungicide as recommended dose. One cutting was placed in a plastic bag (20×30 cm). Pots were fertilized three times (before spring growth cycles, at early and late summer growth cycles) by NPK fertilizer compound (19 N: 19 P_2O_5: 19 K_2O). Foliar application with micronutrients was done three times after soil fertilization. The irrigation was done when cuttings needed.

2.3 Treatments

Each cutting was subjected to 8 treatments, with sixteen cutting as replicates of used as follows:

Control 1 (untreated-uninfected plants).

Control 2 (untreated-Infected plants with *Meloidogyne incognita* nematode).

Jojoba oil at 5%.

Jojoba oil at 10%.

Jojoba oil at 5% + *Meloidogyne incognita* infection.

Jojoba oil at 10% + *Meloidogyne incognita* infection.

Bio-nematicide (Nema-Foo®) at 5% + *Meloidogyne incognita* infection.

Bio-nematicide (Nema-Foo®) at 10% + *Meloidogyne incognita* infection.

It is worth mentioned that all investigated materials were added as a second dose to treated plants in the second week of April 2016 (the beginning of the second season) for the purpose of nutrition and increasing tolerance to root-knot nematode.

2.4 Measurements

At the end of the summer, eight cuttings per treatment were taken to determine treatments impact, for the 1st season, others were left to the 2nd season.

Vegetative Growth

Cane length (cm), cane thickness (mm) "at 5 cm from the main branch", number of leaves, leaf area (cm^2) "estimated according to the formula of Sourial et al. (1985)" /plant were measured at the beginning (mid of April) and the end of experiment (end of October), expressed in rate growth (%) as follows: (the end reading - the initial reading / the initial reading 100). Absorbed roots length (cm), number of adventitious roots, fresh and dry weights (g) of both shoot and root, were determined at the end of the experiment.

2.5 Leaf nutrient contents

Leaves (including petioles) washed, dried at 70^o C till constant weight, then grinded and digested to determine the macronutrients (N, P and K) and micronutrients (Fe, Mn and Zn) according to Burt (2004).

2.6 Nematode parameters

Observations of *Meloidogyne incognita* parameters as numbers of juveniles (J_2) in soil, J_2 in roots, egg-masses and galls in roots of treated grapevine cv. Flame Seedless as well as untreated control were recorded after 6 months. The juveniles of nematode were extracted in soil samples of grapevine plants by sieving and decanting methods (Barker, 1985). Numbers of egg-masses and galls were estimated in roots (5 g per plant) using a binocular microscope (Mai and Lyon, 1975). Rate of build-up was calculated according to the following formulae (Oostenbrink, 1966).

Rate of build- up = Total nematode populations in soil and roots (Pf) / Initial population of J_2 at cutting time Pi (Pi =2000 J_2).

where, Pf is number of J_2 in soil, number of J_2 and egg-masses in roots.

2.7 Statistical analysis

Data were subjected to statistical analysis using computer based software "MS-Excel" and results were submitted to analysis of variance (Snedecor and Cochran, 1989). Differences among treatment means were determined by using the LSD test at a significance level of 0.05 (Waller and Duncan, 1969).

3 Results and discussion

3.1 Effect of Nema-Foo® and Jojoba Oil concentrations on nematode parameters infecting Flame Seedless grapevine cuttings

Data in Table 1 showed that the tested materials as soil drench significantly reduced *M. incognita* numbers of juveniles (J_2) in soil and J_2, galls and egg-masses in roots of Flame Seedless grapevine cuttings as well as rate of build-up, comparing with the control (infected plants), after six months of treatment in seasons 2015 and 2016. There was a positive correlation between reduction percentages of total nematode populations, build-up and tested concentration of jojoba oil and Nema-Foo®, as the highest concentration (10%) of treatment used the highest percentage of nematode reduction occurred, in both seasons.

Table 1 Effect of Nema-Foo® and jojoba oil against *Meloidogyne incognita* parameters infecting Flame Seedless grapevine cuttings during 2015 and 2016 seasons

Treatments	Con., %	No of J_2 in soil (200 g)		No of J_2 in roots (5 g)		No. of galls		No. of egg-masses		Total nematode population		Rate of build-up	
		2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control (Infected plant)	-	10840	6100	517	2870	46	98	35	86	11392	9056	5.7	4.53
Nema-Foo®	5	467	847	187	603	14	66	10	48	664	1498	0.33	0.75
	10	447	713	128	333	10	60	7	37	582	1084	0.29	0.54
Jojoba oil	5	1320	793	233	457	17	51	10	40	1563	1290	0.78	0.65
	10	690	660	50	217	9	30	11	17	751	894	0.37	0.45
$LSD_{0.05}$		73	330	28	238	4.8	11.1	3.6	8	80	482	0.04	0.24

Regarding percentage reduction of J_2 number in soil, Nema-Foo® of each concentration achieved the highest percentage reduction, in the first season, followed by jojoba at (10%). Meanwhile, jojoba oil surpassed Nema-Foo® in the second season followed by Nema-Foo® at the same concentration (Table 2). The same trend occurred for percentages of total nematode and build-up, in the first season, all used concentrations achieved higher percentage reduction of nematode parameters comparing to the second season, it is maybe due to the reduction of nematode reproduction in Flame Seedless roots. Jojoba oil and Commercial product of jojoba oil were effective in managing *M. incognita* in soil and roots with Flame Seedless grapevine cuttings. These results agreed with (Abd-Aziz et al., 1996; El-Nagdi, 2005; El-Nagdi et al,. 2009; and Ahmed et al., 2012). The inhibition of *M. incognita* population as a result of using essential oils maybe due to accumulation of toxic by–products of decomposition and/or increase phenolic contents resulting in host resistance (Kamal et al*.*, 2009). The jojoba oil contains two glycosides with toxic effects: Simmondsin [2-(cyanomethyene)-3- hydroxyl-4, 3-dimethoxycyclohexyl-D gluoside] at 2.3% and Simmondsin -2-ferulate at 1% (Verbiscar and Banigan, 1978). The nematicidal effect of the tested oil may possibly be attributed to its contents of certain nematicidal compounds such as oxygenated compounds which are characterized by both their lipophitic properties which enable them to dissolve the cytoplasmic membrane of nematode cells and their functional groups interfering

Table 2 Percentage reductions of *Meloidogyne incognita* parameters on Flame Seedless grapevine cuttings during 2015 and 2016 seasons

Treatments	Con., %	No of J_2 in soil (200 g)		No of J_2 in roots (5 g)		No. of galls		No. of egg-masses		Total nematode population		Rate of build-up	
		2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Nema-Foo®	5	95.7	86.1	63.8	79	69.6	32.7	71.4	44.2	94.2	83.5	94.2	83.4
	10	95.9	88.3	75.2	88.4	79.3	38.8	80	57	94.9	88	94.9	88.1
Jojoba oil	5	87.8	87	54.9	84.1	63	48	71.4	53.5	86.3	85.8	86.3	85.3
	10	93.6	89.2	90.3	92.4	80.4	69.4	68.6	80.2	93.4	90.1	93.5	90.1

with the nematode enzyme protein structure (Knoblock et al., 1989). In addition, some of the recent hypotheses concerning mechanisms of action of plant oils include denaturing and degrading of enzyme action, and interference with electron flow in the respiratory chain or with adenosine diphosphate phosphorylation (Konstantopoulou et al., 1994).

3.2 Effect of Nema-Foo® and Jojoba Oil concentrations on Performance of Flame Seedless grapevine cuttings uninfected or infected with *M. incognita*

3.2.1 Growth Vigor

Results in Table 3 explained that the increase growth rate to cane length and thickness, no. of leaves and leaf area of Flame Seedless grapevine cuttings were significantly affected by the different treatments in both seasons. Uninfected cuttings treated with the two concentrations of jojoba oil had significant tallest and thickest stems, whereas the same treatments with *M. incognita* infection gave the highest statistical values of no. of leaves and leaf area when compared with the control (uninfected and infected plants) respectively. The best results were obtained as the high concentration of jojoba oil used, which recorded the highest means in different characteristics. Meanwhile, either uninfected or infected control recorded the lowest value of this connection. It is worth mentioned that number and area of leaves were improved when cuttings treated by jojoba oil especially that infected with nematode, perhaps it is due to increase the resistance.

Data in Table 4 clarified that all treatments showed positive effect on absorbed roots length, number of adventitious roots, shoot and root fresh and dry weights of Flame Seedless grapevine cuttings in the two seasons. It is obvious from data that jojoba oil treatments gave the highest values, including the two concentrations used with infected plants as it surpassed Nema-Foo® influence. Control showed the lowest values in this respect without any internal differences between infected and uninfected plants in shoot and root fresh weight in the two seasons, except root fresh weight in the 2nd one.

3.2.2 Nutritional Status

In general, Table 5 results revealed that all treatments had a positive effect on nutritional status as compared with the control (uninfected and infected plants). Concerning leaves content of macroelements, the highest significant N values were obtained by cuttings treated with 10% jojoba oil with or without nematode infection followed by 5% jojoba oil with nematode infection. While, jojoba oil used at 10% on uninfected plants, 5% on infected plants and Nema-Foo at 10% gave the highest values of leaf P & K contents, consecutively. On the other hand, the lowest statistical values were recorded by infected and uninfected control, respectively, in the two seasons.

Regarding leaves content of microelements, it can be noticed that cuttings treated with 10% Nema-Foo® achieved the highest significant values (in leaves Fe and Mn content), followed by 10% jojoba oil on uninfected and infected plants (in leaf Fe content), 10% jojoba oil with uninfected plants and 5% jojoba oil with infected plants (in leaf Mn content). Meanwhile, in leaf Zn content, 10% jojoba oil with infected plants and 10% Nema-Foo® gave higher leaf Zn content, successively. In contrast, the lowest significant leaf Fe, Mn and Zn contents were recorded with the control plants (both infected and uninfected), consecutively in both studied seasons.

Table 3 Effect of Nema-Foo® and jojoba oil concentrations on increase growth rate of Flame Seedless grapevine cuttings uninfected or infected by *Meloidogyne incognita* during 2015 and 2016 seasons

Treatments	Con., %	Root-knot nematode	Cane length, cm		Cane thickness, mm		Number of leaves		Leaf area, cm^2	
			2015	2016	2015	2016	2015	2016	2015	2016
Control	-	Without	46.5	20.2	4.9	7.87	42.6	44.1	27.5	11.4
		With	43.6	17.4	3.2	4.76	30.0	37.0	14.1	9.4
Nema-Foo®	5	With	53.6	68.5	5.2	8.33	42.9	41.7	31.9	13.6
	10		58.4	81.1	7.5	9.52	46.7	44.4	34.5	15.6
Jojoba oil	5	Without	64.1	83.7	12.3	15.9	46.9	48.6	38.3	22.3
		With	47.6	30.6	7.5	8.10	51.8	60.0	42.9	25.7
	10	Without	67.5	87.2	15.3	22.2	48.2	58.8	41.7	24.5
		With	54.1	63.1	11.9	9.72	60.7	76.6	44.2	27.4
$LSD_{0.05}$			0.9	1.04	1.3	0.22	0.6	0.8	0.80	1.1

Table 4 Effect of Nema-Foo® and jojoba oil concentrations on vegetative growth measurements of Flame Seedless grapevine cuttings uninfected or infected by *Meloidogyne incognita* during 2015 and 2016 seasons

Treatments	Con., %	Root-knot nematode	Absorbed roots length, cm		Number of adventitious roots		Fresh weight, g		Fresh weight, g		Dry weights, g			
							Shoots		Root		Shoots		Root	
			2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control	-	Without	16.7	54	16	19	26.2	34.4	17.8	84.5	11.4	15	14.6	30.4
		With	6.5	53.8	13	17	25.9	34.2	17.5	77.6	8.9	15.8	11.6	24.8
Nema-Foo®	5	With	17.7	57	18	22	32.8	42.9	27	95.5	12.7	24.1	14.7	31.8
	10		23.3	72.5	22	27	41.9	54.5	35.4	109.2	14.1	32	18.7	49.2
Jojoba oil	5	Without	17.7	65.7	18	26	37.1	43.9	28.8	107.7	13.3	25.83	15.6	34.8
		With	27	80.2	22	38	45.5	54.6	37.7	111.1	14.2	34	20.2	50.9
	10	Without	20	67.3	22	27	38.6	49.6	30.4	100.6	13.8	29.6	18	39.3
		With	37.2	91.7	24	29	46.1	61.8	37.9	143.4	15.6	37.3	22.2	60.4
$LSD_{0.05}$			1	2.5	0.9	1.3	0.94	0.91	0.8	1.32	0.91	0.94	0.91	0.94

Table 5 Effect of Nema-Foo and jojoba oil concentrations on Nutrition status of Flame Seedless grapevine cuttings infected by *Meloidogyne incognita* or without during 2015 and 2016 seasons

Treatments	Con., %	Root-knot nematode	Macroelements, %						Microelements, ppm					
			N		P		K		Fe		Mn		Zn	
			2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control	-	without	1.95	2.08	0.59	0.38	1.83	1.62	410	221	103	75	81	49.9
		with	1.78	1.57	0.51	0.3	0.78	1.3	192	173	103	50	28	42.3
Nema-Foo®	5	with	2.43	2.17	0.58	0.43	2.08	2.01	410	203	110	80	82	57.2
	10		2.51	2.17	0.63	0.65	2.18	2.4	726	257	156	96	92	72.4
Jojoba oil	5	without	2.43	2.11	0.56	0.63	2.03	2.21	483	192	111	75	87	57.5
		with	2.51	2.23	0.76	0.77	2.2	2.73	483	203	116	80	89	63.3
	10	without	2.67	2.24	0.78	0.93	2.43	3.12	675	227	144	83	88	61.6
		with	2.79	2.56	0.62	0.66	2.13	2.53	629	219	111	76	95	72.9
$LSD_{0.05}$			0.09	0.09	0.06	0.09	0.13	0.13	1.1	1.2	0.9	0.94	1.1	0.82

Enhancement action for all growth aspects and nutritional status of Flame Seedless grapevine was maybe due to the activation of jojoba oil “accounting for about 40%-60% of the seed weight”. It is completely different from all vegetable oils due to its structure where chemically classified as liquid wax with the union of fatty acids and a series of a long carbon chain (40-44 carbon atoms). Research has shown that jojoba featuring six properties that increase the ability to hack, namely: low-viscosity, high percentage of desaturation, the low number of saponification (Mostafa et al., 2017). Dry weight of plant is an important standard for evaluating vigor in all plants, results signed an upward increase in shoots and root dry weights with increasing jojoba oil concentration as well as the observed effect of jojoba oil extracts improving roots growth of cuttings might be attributed to elements absorption and translocation to roots (Kesba, 2003). Moreover, increasing the soil area occupied by the roots due to the application of this oil, nematodes presented in the soil distribute over a considerably large area of soil (El-Gendy and Shawky, 2006). It was also mentioned that products caused the release of macroelements and converted them to soluble forms of N, P and K which by their turn had a positive effect on all aspects of vegetative growth. Furthermore, these products increased area of soil occupied by the roots which shown later by the enhanced uptake of water and minerals. In addition, they can also break down certain complex minerals and organic substances in the soil and make it available to roots (Soliman et al., 2011). Similar results were published by many authors Sönmez, et al. (2010), Raheleh (2011), Hafez-Omaima et al. (2012) and Hamouda et al. (2015).

4 Conclusion

From our results, it can be concluded that, natural alternatives must be used in grapevine orchards such as jojoba oil and commercial jojoba products. It had a positive impact on all the vegetative growth parameters, plants growth vigor and tolerance as well as controlling root-knot nematode. Furthermore, it does not cause damage to the environment, human and animal.

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