Assessing efficacy of jojoba crushed seed and oil cake on growth vigor, nutritional status of Superior grapevine cuttings and controlling the root-knot nematode

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Abstract: The increasing demand for environmental protection and sustainable food production requires increasing towards the use of natural and non-toxic materials for agriculture. Thus, the target of the current research was to assess the efficacy of jojoba crushed seed, oil cake (seed after compressing) and bio-nematicide (Nema-Foo®) on growth and nutritional status of Superior grapevine cuttings as well as controlling *Meloidogyne incognita* in the Pomology greenhouse at NRC, Dokki, Giza, under Egyptian conditions during two successive seasons (2015-2016). Eleven treatments were done on Superior grapevine cuttings (one year old) as jojoba crushed seed and jojoba oil cake (3 and 6 g, for each) with or without infection, Nema-Foo® (5%) with infection were added, in addition to untreated control (infected and uninfected plants). Generally, our results showed that all studied growth parameters, nutritional status and resistance to nematodes of Superior grapevine cuttings were affected by various treatments. Jojoba crushed seed and oil cake had a promotion effect as they increased most of the growth parameters, leaf nutrient contents and controlling root-knot nematode. The higher dose of these materials (6 g) showed higher effect on the previous measurements. It is worth mentioning that jojoba crushed seed were more effective than jojoba oil cake in this regard.

Keywords: superior grapevine cutting, vegetative growth, nutritional status, controlling root-knot nematode

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1 Introduction

Grapevine (*Vitis vinifera* L.) is one of the most widely cultivated fruit crops in the world. In Egypt, grapevine ranks the second after Citrus among fruit crops. Grapevines cultivated area increase recently. According to the Ministry of Agriculture Statistics (2013), it reached 188543 feddans producing 1378815 tons. Superior is one of the newly introduced grapevine cultivars in Egypt. It is an early cultivar that meets the requirements of local as well as foreign markets, such as some Arab and European countries. It suffers from several factors which have a negative effect on growth, yield and fruit quality. Nematodes-spreading is the most common one among 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 chemical nematicide to manage is being discouraged because of their polluting effects and creating health hazards in human and animals. An alternative control measure may be the use of antagonistic plants (El-Nagdi, 2005 & 2006). Jojoba (*Simmondsia chinensis* L.) has been found to suppress the population of certain phytonematodes by releasing nematoxin into the soil when being grown with susceptible crops or adding their extracts or other products to the soil (El-Nagdi, 2009; Ismail, et al., 2009; Ahmed et al., 2012; Abdelmaksoud,

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2014; El-Saedy et al., 2015).

Jojoba seed contains about 50% waxy oil which could be extracted by compressing, with loss of about 10% oil in its residue. Jojoba cake is the remained material (residue) of seed after compressing and extraction of jojoba oil. It contains 24-33% protein including seventeen amino acids; seven of them are essential acids with high rates, and about 10% oil (Yermanos, 1975). Oil seed cake may suppress plant parasitic nematodes in economically important crops (Radwan et al., 2009).

The objectives of this study were to determine the potential of jojoba crushed seed, oil cake (seed after compressing process) and bio-nematicide (Nema-Foo®) on growth and nutritional status of Superior grapevine cuttings as well as controlling *Meloidogyne incognita* under greenhouse conditions.

2 Materials and methods

2.1 Plant Material

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

2.2 Soil Preparation

The soil was consisted of peat moss and sand at 1:2 as volume, 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 cycle and at early and late summer growth cycles) using 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

Superior grapevine cuttings were subjected to eleven treatments and each treatment had twelve cuttings as replicates. Treatments were as follows:

1- Control (untreated-uninfected plants).

2- Control (untreated-Infected plants with root-knot nematode).

3- Jojoba oil cake at 3 g/plant.

4- Jojoba oil cake at 6 g/plant.

5- Jojoba crushed seed at 3 g/plant.

6- Jojoba crushed seed at 6 g/plant.

7- Jojoba oil cake at 3 g/plant + root-knot nematode.

8- Jojoba oil cake at 6 g/plant + root-knot nematode.

9- Jojoba crushed seed at 3 g/plant + root-knot nematode.

10- Jojoba crushed seed at 6 g/plant + root-knot nematode.

11- Bio-nematicide (Nema-Foo®) 5% + root-knot nematode.

It is worth mentioning that these materials had been added as a second addition to the plants in the second week of March 2016 (the beginning of the second season) to ascertain their influence.

2.4 Measurements

At the end of the summer season, six cuttings / treatment were collected for evaluation in the 1st season and the others were left to the 2nd season.

2.5 Vegetative Growth

Cane length (cm), cane thickness (mm) "at 5 cm from the main stem", number of leaves, leaf area (cm^2) were estimated according to the formula of Sourial et al. (1985). The plants were measured at the beginning (mid of March) and the end of experiment (end of September), and the data was expressed in growth rate (%) as follows: (the end reading - the initial reading /the initial reading X 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 experiment.

2.6 Leaf nutrient contents

leaves with petioles were washed, dried at 70°C till constant weight, then grinded and digested to determine the macro nutrients (N, P and K) and micronutrient (Fe, Mn and Zn) according to Rebbeca (2004).

2.7 Nematode parameters

Observations of *M. incognita* parameters as numbers of juveniles (J_2) in soil, J_2 in roots, egg-masses and galls in roots of treated grapevine cv. Superior 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.

2.8 Statistical analysis

The 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 jojoba seed oil cake, crushed seed levels and Nema-Foo® on performance of Superior grapevine cuttings increasing rate of some vegetative growth characteristics

Table 1 shows that increasing rate of some vegetative growth was affected by the investigated treatments.

Table 1 The increasing rate of some vegetative growth measurements of Superior grapevine cuttings infected by root knot nematode or without as affected by treatments during 2015 and 2016 seasons

Treatments	Dose, g	Root-knot nematode	Cane length, cm		Cane thickness, mm		Number of leaves		Leaf area, cm^2	
			1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	-	without	30.9	16.0	14.44	6.73	34.48	23.70	34.06	22.23
		with	26.3	10.5	3.70	2.56	17.18	23.45	25.43	13.31
Nema-Foo®	5%	with	41.2	25.2	20.74	4.48	28.03	44.76	36.43	45.82
Jojoba seed oil cake	3	without	43.9	20.7	7.87	5.66	26.41	29.60	27.91	22.36
		with	34.6	10.6	7.87	9.09	38.46	36.84	53.36	32.79
	6	without	46.1	45.2	7.50	16.67	36.63	52.17	44.15	20.28
		with	44.2	24.1	4.17	11.67	48.10	33.81	55.47	30.16
Jojoba crushed Seed	3	without	29.6	17.7	4.17	9.09	39.19	38.39	55.50	21.01
		with	35.1	15.3	4.17	11.67	49.05	60.11	43.31	48.14
	6	without	51.0	50.5	7.87	4.78	30.85	48.74	58.32	30.60
		with	44.7	32.0	17.41	16.00	50.00	74.19	53.37	49.84
	$LSD_{0.05}$		10.9	0.86	10.2	0.84	19.8	1.19	11.3	1.31

In general, the obtained results revealed that the growth vigor of Superior grapevine cuttings (cane length and thickness, number of leaves and leaf area) was clearly affected by all treatments including the root-knot nematode which reduced the growth vigor as a result of infection to the roots. It is worth mentioning the measurements improved by using the investigated jojoba products (seed oil cake, crushed seed levels and Nema-Foo®) during the two successive seasons in current study. The higher dose of those materials (6 g) showed the highest positive effect on the previous measurements and on the contrary in case of the lower one (3 g). The jojoba crushed seed was more effective than jojoba oil cake in this respect. Meanwhile, the control (untreated-infected plants) recorded the statistical reduction in the previous parameters in both studied seasons.

3.1.1 Vegetative growth measurements

Several growth parameters of Superior grapevine cuttings influenced by treatments of jojoba seed oil cake, crushed seed levels and Nema-Foo® were determined. They included absorbed roots length, number of adventitious roots, fresh and dry weights (shoot and root), which presented in (Table 2).

It is clear that plant growth measurements obtained were affected by treating with jojoba crushed seed, seed oil cake and Nema-Foo®. Also, data showed that cuttings treated with higher doses of jojoba crushed seed and seed oil cake were superior in these measurements significantly during the two consecutive seasons. On the contrary, the untreated cuttings produced the minimum values in this respect.

Table 2 Vegetative growth measurements of Superior grapevine cuttings infected by root knot nematode or without as affected by treatments during 2015 and 2016 seasons

Treatments	Dose, g	Root-knot nematode	Absorbed roots length, cm		Number of adventitious roots		Fresh weight, g		Fresh weight, g		Dry weights, g			
							Shoots		Root		Shoots		Root	
			1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	-	without	21.34	42.67	16.33	23.50	34.69	45.09	34.69	45.09	51.82	101.1	14.84	22.44
		with	15.61	25.44	11.33	9.00	22.92	34.09	26.23	70.23	10.84	18.73	12.32	31.90
Nema-Foo® (%)	5	with	42.28	57.50	22.33	25.00	44.42	49.54	46.31	148.6	18.29	27.16	16.26	46.55
Jojoba seed oil cake	3	without	24.72	37.96	16.0	19.00	35.27	47.15	55.44	101.2	15.02	19.13	20.66	51.67
		with	23.61	53.11	16.00	21.67	39.65	47.23	38.27	74.95	16.79	27.45	21.40	49.06
	6	without	24.56	37.00	15.67	13.67	41.26	51.13	55.69	134.5	14.74	28.55	17.94	53.10
		with	18.42	39.06	14.33	23.00	34.53	43.71	35.65	98.14	13.31	20.82	16.15	38.57
Jojoba crushed seed	3	without	38.22	56.26	18.33	24.50	34.87	40.12	31.78	99.84	16.98	21.40	15.95	34.29
		with	16.83	51.78	18.67	18.50	30.30	35.85	31.45	107.9	15.64	19.87	12.13	45.51
	6	without	31.89	46.89	12.67	19.33	27.20	48.07	34.91	88.47	15.31	22.37	17.62	36.07
		with	21.06	47.33	14.67	21.67	45.12	52.12	60.84	130.1	15.31	27.44	22.13	82.42
LSD 0.05			0.86	2.05	1.67	2.5	0.86	1.02	0.85	1.03	0.94	0.89	1.94	0.86

From the previous results, it was found that treatments with crushed seed levels improved all aspects of Superior grapevine growth vigor (cane length and thickness, number of leaves, leaf area, absorbed roots length and number, fresh and dry weights (shoot and root). That may be attributed to the content of jojoba seed waxy oil **(**about 50% by weight). Similar results were obtained with seed oil cake which contains about 10% oil. In addition, jojoba seed contains 24-33% protein including seventeen amino acids and seven of them are essential acids with high rates (Yermanos, 1975). These contents might stimulate the biosynthesis of organic materials, especially carbohydrates and proteins, and enhance the formation and movement of natural hormones, which are vital to improve cell division, especially in the meristematic tissues (Nijjar, 1985). Our results in grapevine are agreed with the previous findings (El-Nagdi et al., 2009; Ahmed et al., 2012; El-Saedy et al., 2015) as jojoba oil enhanced growth of grapevine under nematode condition due to faster absorption of water nutrients via roots.

3.1.2 Nutritional status

Our results indicated that, in the two studied seasons, all treatments showed a positive effect on the nutritional status of Superior grapevine cuttings when compared with the control (infected and uninfected plants).

3.1.3 Macroelements

Concerning treated cuttings with jojoba crushed seed and seed oil cake, higher dose (6 g/plant) gave the highest leaf macroelements contents of these cuttings at all elements under investigation (N, P, K). In addition, jojoba crushed seed treatments gave higher macroelements contents than seed oil cake. As shown in Table 3, concerning Nema-Foo® treatment, its dose gave higher macroelements contents than the control and it surpassed the investigated jojoba products in K content at the first season and N at the second season only.

Table 3 Macroelements of Superior grapevine cuttings infected by root knot nematode or without as affected by treatments during 2015 and 2016 seasons

Treatments	Dose, g	Root-knot nematode	Macroelements, %					
			N		P		K	
			1st	2nd	1st	2nd	1st	2nd
Control	-	Without	2.23	1.92	0.37	0.58	1.53	0.58
		With	1.69	1.81	0.06	0.34	1.13	2.14
Nema-Foo® (%)	5	With	2.17	2.65	0.46	0.69	3.12	1.98
Jojoba seed oil cake	3	Without	2.45	1.98	0.39	0.28	1.73	2.40
		With	2.45	2.14	0.34	0.10	1.83	2.40
	6	Without	2.57	2.31	0.51	0.42	1.75	2.66
		With	2.55	2.14	0.66	0.76	1.88	2.73
Jojoba crushed seed	3	Without	2.57	1.98	0.40	0.58	1.63	2.70
		With	2.57	1.95	0.42	0.19	1.70	2.73
	6	Without	2.57	2.32	0.64	0.75	1.83	2.74
		With	2.57	2.25	0.69	0.81	2.15	3.12
$LSD_{0.05}$			0.02	0.09	0.02	0.02	0.15	0.03

3.1.4 Microelements

As shown in Table 4, all investigated treatments gave positive effect on microelements leaf contents compared with the control (infected plants). Moreover, the higher dose of both jojoba crushed seed and seed oil cake with nematode infection recorded the highest statistical leaf

content of Fe and Zn even compared with the uninfected control plants. Concerning Mn leaf content, higher dose of crushed seed, without nematode infection, had the highest values in both seasons.

Table 4 Microelements of Superior grapevine cuttings infected by root knot nematode or without as affected by treatments during 2015 and 2016 seasons

Treatments	Dose, g	Root-knot nematode	Microelements, ppm					
			Fe		Mn		Zn	
			1st	2nd	1st	2nd	1st	2nd
Control	-	Without	386	200	92	76	71	22.5
		With	365	200	90	35	38	19.4
Nema-Foo® (%)	5	With	389	311	99	78	70	54.9
Jojoba seed oil cake	3	Without	397	254	130	81	64	42.7
		With	429	262	105	61	45	45.0
	6	Without	548	335	132	128	71	60.7
		With	572	337	119	111	72	79.6
Jojoba crushed seed	3	Without	508	292	138	96	68	44.5
		With	546	302	109	114	66	51.7
	6	Without	559	273	140	138	72	72.0
		With	586	354	131	118	89	94.0
$LSD_{0.05}$			1.32	1.31	1.91	1.28	1.42	1.93

Enhancement in nutrient status following the treatment with jojoba crushed seed and seed oil cake of Superior grapevine especially the high doses of these products may be due to the higher content of many soil nutrients **(**Yermanos, 1975), which stimulate and encourage the translocation of nutrients from soils via roots, as well as improve the minerals uptake, increase the size of root system and consequently increase the root surface adsorption (Shawky et al., 2010; Soliman et al.,2011) The appropriate supply of nutrients are very important and positively affect plant growth and photosynthesis especially potassium element, which has crucial role in plant growth and health by improving activating ATP production, enhancing photosynthesis and phenolic biosynthesis (Krauss, 1999), increasing root strength and sturdy stems and transporting nutrients to the xylem (Turner and Barkus, 1983). These processes enhance sugar formation, neutralization of organic acids as well as increase protein that led to better effect on both cell division and cell elongation. In this respect, the present results are in agreement with those obtained by Hafez-Omaima, *et al*. (2012) and Hamouda *et al*. (2015).

3.2 Effect of jojoba seed oil cake, crushed seed levels and Nema-Foo® on Nematode parameters

Results presented in Table (5) indicated that the jojoba oil cake and crushed seed as well as commercial products of Nema-Foo® reduced significantly numbers of each J_2 in soil, J_2 in roots and the number of galls and egg-masses in roots of grapevine cv. Superior as well as rate of build-up comparing with untreated (control) after 6 months of treatment in seasons 2015 and 2016. There was a positive correlation between reduction percentages of total nematode populations, rates of build-up and tested dose of each material, as higher dose (6 g/plant) of treatment occurred; there was a higher percentage of nematode reduction in both two seasons.

Table 5 Effect of jojoba seed oil cake, crushed seed and Nema-Foo® on root-knot nematode parameters infecting Superior grapevine cuttings during 2015 and 2016 seasons

Treatments	Dose, g	No of J_2 in soil (200 g)		No of J_2 in roots (5 g)		No. of galls		No. of egg-mases		Total nematode population		Rate of build-up	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Infected plant	-	4647	3780	1517	3300	102	183	85	94	6249	7174	3.12	3.59
Jojoba seed oil cake	3	1830	473	383	603	22	74	14	42	2227	1118	1.11	0.56
	6	930	440	360	125	19	41	12	29	1602	594	0.80	0.30
Jojoba crushed seed	3	1247	480	640	634	28	96	19	49	1906	930	0.95	0.47
	6	1137	403	327	400	24	67	15	30	1479	833	0.74	0.42
Nema-Foo®	5%	1567	350	333	650	18	92	15	40	1915	1040	0.96	0.52
$LSD_{0.05}$		73	165	32.5	241	14.4	16.9	4.9	5.9	393	402	0.2	0.2

Data also showed a considerable decrease in galls with the increasing rate of the jojoba seed oil cake and crushed seed compared with the value recorded in the control treatment. Higher dosage rates resulted in greater effects in reducing the number of galls than lower rates.

Jojoba crushed seed gave highly reduced total nematode followed by jojoba seed oil cake at 6 g/plant in

the first season while in the second season jojoba seed oil cake gave highly reduced in the same dosage compared to untreated control (Table 5). The highest reduction percentage of build-up were achieved by jojoba seed oil cake (91.6%) followed by jojoba crushed seed (88.3) at 6g/plant compared to Nema-Foo® (85.5%) in the second season (Table 6). All dosage rates in the second season gave effect to reduce nematode parameters because this season added the materials again for the purpose of feeding and increasing their resistance.

Table 6 Percentage reductions of the root-knot nematode parameters infecting Superior grapevine cuttings as affected by treatments during 2015 and 2016 seasons

Treatments	Dose, g	No of J_2 in soil (200 g)		No of J_2 in roots (5 g)		No. of galls		No. of egg-mases		Total nematode population		Rate of build-up	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Jojoba seed oil cake	3	60.6	87.5	74.8	81.7	78.7	59.6	85.5	55.3	64.4	84.4	64.4	84.4
	6	78.0	88.4	76.3	96.2	81.4	77.6	85.9	69.1	74.4	91.7	74.4	91.6
Jojoba crushed seed	3	73.2	87.3	57.8	80.8	72.5	47.5	77.6	47.9	69.5	87.0	69.6	86.9
	6	75.5	89.3	78.4	87.9	76.5	63.4	82.4	68.1	64.3	88.4	76.3	88.3
Nema-Foo®	5%	66.3	90.7	78.0	80.3	82.4	49.7	82.4	57.4	69.4	85.5	69.2	85.5

Jojoba seed oil cake and crushed seed were used as organic amendments, which showed promising nematicidal activity in the control of *M. incognita* infecting Superior grapevine cuttings in two seasons. The similar results were also obtained by El-Nagdi et al. (2009), Ahmed et al. (2012) and El-Saedy et al. (2015). Oil cake had been demonstrated to incite the soil microflora to release some substances, which is fungicidal and nematicidal (Tousson et al., 1964). Besides these, a possible explanation for nematode control obtained by oil cake, might be due to the release of some toxic chemicals during the decomposition process (Alam et al. 1979). There is an increase in phenolic contents, result in host resistance by protecting plant roots from larval invasion and producing ammonia by amonifying bacteria during natural decomposition of nitrogenous organic material (Rodriguez-Kabana, 1986). 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).

4 Conclusion

It can be concluded that using crushed jojoba seed and seed oil cake as organic amendments showed improvement in growth vigor and nutrition status of Superior grapevine cuttings. They also presented a protection role from nematodes injury, which help consider them as a promising bio-nematicide, environmentally safe.

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