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EFFICACY OF GROWTH MEDIUM (MURASHIGE&SKOOG) SUPPLEMENTED WITH CERTAIN ESSENTIAL OILS ON TOMATO ROOTS SUITABILITY TO *Meloidogyne incognita* INFECTION UNDER GREENHOUSE CONDITIONS.

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ABSTRACT

The influence of six essential oils i.e. garlic, sesame, neem, castor, chamomile, and linseed added to aseptic culture (MS medium) used for growth of tomato seedlings cv Strain-B before transplanting in pots with sterilized sandy loam soil on *Meloidogyne incognita* infection was studied under greenhouse conditions 30±5°C. Results indicated that all of the tested essential oils introduced into growth media protected and improved tomato plant growth of either the infected or uninfected with nematodes to a certain extent. Among all tested materials, castor oil gave the highest increment in fresh weight of the whole plant either infected or uninfected with values of 135.42% and 217.59%, respectively. The same trend was observed with castor oil in respect to increasing shoot dry weight of the healthy tomato plants (37.14%) whereas recorded the second to linseed oil treatment with the infected plants with values of 32.56% and 35.2%, respectively. Moreover, sesame oil application achieved the second values to castor oil treatment in increase percentage of both fresh weight of whole plant (132%) as well as shoot dry weight (29.24%), respectively. The highest reduction percentage in nematode population was obtained with castor oil treatment which amounted to 93.53% followed by linseed oil application with value of 92.71%. Among all tested essential oils, sesame oil significantly decreased number of galls on tomato roots with reduction percentage of 90%, followed by those treated with either chamomile or linseed oils with value of 87.5% each. *M. incognita* did not produce egg-masses on plants treated with all of the tested materials and considered as highly resistant due to egg-masses indices (zero each) whereas those received linseed oil as very resistant with egg-masses index value of 3 and reduction percentage value of 97.4%.

Keywords: Aseptic culture (MS medium), essential oils, *Meloidogyne incognita*, tomato, resistance.

INTRODUCTION

Tomato (*Lycopersicon esculentum* L.) is the world's largest vegetable crop and known as productive as well as protective food. Moreover, tomato is one of the most important commercial and dietary vegetable crops all over the world as well as in Egypt. In 2005, Egypt ranked the fourth among the five top producers of tomatoes in the world which cultivated on 464286 feddans producing 7.600.000 tons according to FAOSTAT.

One of the serious pathogens affecting tomato production is plant parasitic nematodes. Worldwide, crop loss attributed to these pests could be estimated by 20.6% (Sasser and Freckman, 1987).

* this paper is extracted from Ph.D. thesis of the first author.

The root-knot nematodes, *Meloidogyne* spp. are economically important parasites of plants, *M. arenaria, M. hapla, M. javanica* and *M. incognita* are considered the most popular species which caused more than 90% of the estimated damages (Mai, 1985).

The practice of plant tissue culture has contributed towards the propagation of large number of plant from small pieces of stock plants in relatively short period of time (Daniel, 1998). Compared to conventional planting material, tissue culture plants give higher yield; and earlier and more vigorous sucker production. Tissue culture plants are uniform and available all year round as important criteria for commercial farming. Rapid and easy mass production also allow for improvement of selections of plant with enhanced stress or pest resistance.

During the last decades, greater interest has given among scientists to produce plant seedlings free of viral infection by the help of tissue culture technology (Shea, 2005). However, these tissue culture plants are subjected to be attacked by plant parasitic nematodes (Mostafa *et al*., 1992).

Plant parasitic nematodes are controlled by cultural practices, chemical nematicides and the use of resistant cultivars. However, nematicides do not provide long-term suppression of nematodes, and environmental and human health concerns are resulting in increased restrictions on their use. Some safe procedures for nematode control have been developed passed on biological control agents and organic amendments; however, there is still need for alternative, friendly methods or compounds for effective nematode control to be developed (Noling& Becker, 1994).

Essential oils of certain plants and/or their components or products as oil cakes have been tested for nematicidal activity *in vitro* and *in vivo* by several workers (Chatterjee *et al*., 1982; El-Sherif, 1984; Leela *et al*., 1992; Mostafa &Al-Batran, 1998; Oka *et al*., 2000; Pandey *et al*., 2000; Duschatzky *et al*., 2004; and Zaher, 2004).

Results of most previous papers were greatly affected by the percentage of organic matter and clay contents within the soil media of such experiments, since the influence of the essential oils of *Origanum syriacum, O. vulgare* and *Mentha rotundifalia* or Egyptian lupine 1% on root galling of cucumber or sunflower was more prounced in sandy or sandy loam, respectively (Oka *et al*., 2000 and Zaher, 2004).

Trials to control root-knot nematodes affecting tissue culture plants by altering the chemical components of growth medium in order to produce seedlings able to sustain nematode infection has not undertaken.

Therefore, the present study is an attempt to produce successful healthy tomato seedlings by tissue culture able to resist or tolerate the infection by the root-knot nematode, *M. incognita* under greenhouse conditions through the addition of certain essential oils to growth medium (MS).

MATERIALS AND METHODS

Plantlet induction:

Tomato seeds cv Strain-B were shacked for 10 min. in sterilized distilled water provided with some drops of soap, then surface sterilized by immersing in 30% sodium hypochlorite (NaOCl) solution plus a drop of tween

20 for 12 min. Thereafter, these soaked seeds were rinsed three times in sterilized distilled water, and cultivated on autoclaved watered-cotton as a liquid medium in 250 ml jars under aseptic conditions. Ten seeds were distributed randomly in each jar and kept in growth chamber at 25°C with 16 h. light/ 8 h. dark cycle. Seeds were then germinated after three days.

Preparation of the media:

Three-fourth strength MS (Murashige and Skoog, 1962) medium (3.3 g/l) were prepared. The media were solidified with 6 g/l agar and sucrose at 30 g/l. The media were distributed into 375 ml clean jars, contained 300 ml of nutrient media each. The pH was then adjusted to 5.7 before autoclaved process.

Preparation of essential oils:

The following six essential oils, i.e. garlic, sesame, neem, castor, chamomile, and linseed were used in this study. Scientific name and chemical constituents are presented in table (1).

Table (1): Common, scientific and family names as well as chemical constituents of six essential oils used in this study.

Common name	Scientific name	Family name	Chemical constituents	Reference
Garlic	*Allium sativum*	Liliaceae	Allicin, Beta-carotene, Betasitosterol, Caffeic acid, Chlorogenic acid, Diallyl disulfide, Ferulic acid, Geraniol, Kaempferol, Linalool, Oleanolic acid, P-coumaric acid, Phloroglucinol, Phytic acid, Quercetin, Rutin, S-Allyl cysteine, Saponin, Sinapic acid, Stigmasterol and Alliin	Balch, 2000
Sesame	*Sesamum indicum*	Pedaliaceae	Olein, stearin, palmitin, myristin, linolein, sesamin and sesamolin	Simon *et al.*, 1984
Neem	*Azadirachta indica*	Meliaceae	Linoleic acid, palmitic acids, stearic acids, oleic acid, arachidic acid , vitamin E and other essential amino acids.	Hossain, 2005
Castor	*Ricinus communis*	Euphorbiaceae	Ricinoleic acid, oleic acid, linoleic acid linolenic acid, palmitic acid, stearic acids, Dihydroxystearic acid and ricin	Wikipedia, 2007
Chamomile	*Matricaria chamomilla*	Asteraceae	Chamazulene, angelic acid, tiglic acid, anthemic acid, athesterol, anthemene, resin, tannin, spathulenol, farnesene, antheminidine, matricarin, apigenin and sesquiterpene lactones	Simon *et al.*, 1984
Linseed	*Linum usitatissimum*	Linaceae	linolenic acid, linoleic acid, mucilage, Palmitic acid, stearic acid, oleic acid, arachidic acid, protein, and small amounts of linamarin	Wikipedia, 2006

Dried seeds of neem were powdered and soaked overnight in petroleum ether (v/v), then the extract is screened through a piece of cloth. The solvent was then evaporated in the incubator at 40°C for 24 h. Resulted oil was stored in vials at 4°C until used. However, the essential oils of sesame, castor, chamomile, garlic and linseed seeds were obtained as pure oils from AL-Nekeety company, Mansoura city- Egypt.

Nematode inoculum:

Fresh hatching second-stage juveniles of the root-knot nematode *M. incognita* (J_2) were obtained from a pure culture established from single egg-mass of *M. incognita* that previously identified according to the characteristics of its perineal pattern (Taylor& Sasser, 1978) and reared on coleus plants, *Coleus blumei* in the greenhouse of Nematology Research Unit, Faculty of Agriculture, Mansoura University, Egypt.

Impact of certain essential oils on tomato seedlings growth and nematode infection:

The concentration of 0.1% (0.3 ml/ 300 ml medium) of each essential oil under study was added to the medium with a drop of Tween 20, then shaking thoroughly to determine its effect on the seedlings growth against nematode development. Twenty unsupplemented jars with essential oils were served as control. The media were distributed into 250 ml sterile jars, contained 30 ml of medium enriched with essential oil under a sterilized environment within a laminar airflow cabinet. One week old sterilized tomato seedlings cv Strain-B were cultured in previously prepared media. Each treatment of the essential oil tested has ten jars as replicates (each contained 3 explants), kept inside the growth chamber at 25°C under the system of 2000 Lux. fluorescent lamps for 16 h. light and 8 h. dark cycle for three weeks.

Afterwards, one month old tomato seedlings were transferred to 7-cm-diam. plastic pots (one seedling/pot) filled with steam-sterilized mixture of peatmoos and sand (1:1, v:v) for acclimatization. Glass jar was placed on the top of each seedling and kept in a growth chamber as previously mentioned. One week later, these tomato seedlings were transferred to 14-cm-diam. plastic pots (one seedling/pot) filled with 900 g steam-sterilized sandy loam soil (1:1). After one week, eighteen seedlings (45 days old) of tomato were separately inoculated with 1500 fresh hatching second-stage juveniles of *M. incognita* . Three untreated and uninoculated or untreated with any of the essential oil and inoculated seedlings were served as control. Therefore, the treatments were as follows:

1- Garlic oil alone	2- Garlic oil + N
3- Sesame oil alone	4- Sesame oil + N
5- Neem oil alone	6- Neem oil + N
7- Castor oil alone	8- Castor oil + N
9- Chamomile oil alone	10- Chamomile oil + N
11- Linseed oil alone	12- Linseed oil + N
13- Untreated and uninoculated plants (ck)	14- N alone (ck)

Each treatment was replicated three times and all pots were randomly arranged on a greenhouse bench at 30±5°C. Plants were watered regularly as needed.

After 45 days from nematode inoculation, plants were harvested. Data dealing with length of shoot and root, and fresh weights of shoot and root as well as shoot dry weight were determined and recorded. Infected tomato roots were stained in 0.01 acid fuchsin and examined for the numbers of developmental stages, females, galls and egg-masses (Byrd *et al.*, 1983). The root gall index (RGI) and egg mass index (EGI) were estimated according to the scale given by Taylor and Sasser (1978) as follows: 0= no galling or egg-masses, 1= 1-2 galls or egg-masses, 2= 3-10 galls or egg-masses, 3= 11-30 galls or egg-masses, 4= 31-100 galls or egg-masses and 5= more than 100 galls or egg-masses. *M. incognita* (J_2s) were then extracted from soil by sieving and modified Baermann-pan technique (Goody, 1957), counted and recorded. Host suitability was measured according to the scale of Hadisoeganda & Sasser (1982) on the basis of the root gall index or egg-masses index as follows: RGI or EI range of 0.0-1.0= highly resistant (HR), 1.1-3.0= very resistant (VR), 3.1-3.5= moderately resistant (MR), 3.6-4.0= slightly resistant (SR) and 4.1-5.0= susceptible (S). Statistically, the obtained data were subjected to analysis of variance (ANOVA) (Gomez and Gomez, 1984) followed by Duncan's multiple range to compare means (Duncan, 1955).

RESULTS AND DISCUSSION

Data in table (2) document the plant growth of tomato seedlings previously reared on MS medium provided with six essential oils, i.e. garlic, sesame, neem, castor, chamomile and linseed before planting in 900 g sterilized soil/ pot and then infected with *M. incognita* under greenhouse conditions at 30±5°C.

Table (2): Effect of six essential oils added to MS medium on the growth of tomato seedlings transplanted to sterilized soil and infected with *Meloidogyne incognita* under greenhouse conditions.

Treatments	Plant growth response							
	Length(cm)		Fresh weight(g)		Fresh wt. of the whole plant(g)	Increase %	Shoot dry wt. (g)	Increase %
	Shoot	Root	Shoot	Root				
	Infected							
Garlic oil+ N	32.5 ef	27 h	10.42 cde	6.90 b	17.32 cd	97.27	3.75 ab	24.6
Sesame oil+ N	28.5 h	32.5 de	16.65 a	3.72 fg	20.37 a	132.0	3.89 a	29.24
Neem oil+ N	30.2 fgh	34 cd	12.58 bc	4.05 ef	16.63 cde	89.41	3.83 ab	27.2
Castor oil+ N	43 a	22 i	16.85 a	3.82 ef	20.67 b	135.42	3.99 ab	32.56
Chamomile oil+ N	33 ef	35.5 c	10.22 de	5.54 bcd	15.76 cde	79.49	3.77 ab	25.2
Linseed oil+ N	37.5 cd	34.3cd	12.68 b	5.70 bc	18.38 bc	109.34	4.07 ab	35.2
N alone	32.5 ef	28 gh	7.31 fg	1.47 h	8.78 f	----	3.01 b	----
	Uninfected							
Garlic oil	38 bcd	32.5 de	10.28 de	4.17 def	14.45 de	47.75	3.59 ab	13.97
Sesame oil	38 bcd	28.6 fgh	11.73 bcd	4.04 ef	15.76 cde	61.15	3.55 ab	12.70
Neem oil	39 bc	50 b	10.66 bcde	5.16 cde	15.81 cde	61.66	3.77 ab	19.68
Castor oil	41 ab	54 a	15.48 a	15.58 a	31.06 a	217.59	4.32 a	37.14
Chamomile oil	35 de	30.6efg	11.55 bcd	6.30 bc	17.85 bc	82.52	3.83 ab	21.59
Linseed oil	31.6 fg	31.5def	9.20 ef	5.01 cdef	14.21 e	45.30	3.47 ab	10.16
Free of any oil	29 gh	23 i	7.41 fg	2.37 gh	9.78 f	----	3.15 b	----

***Each figure represents the mean of three replicates.**

***Means in each column (including infected and uninfected plants) followed by the same letter did not differ at P< 0.05 according to Duncan's multiple range test.**

N= 1500 *M. incognita* J_2

Results indicated that all of the tested oils were found to be effective in protecting and improving tomato plant growth either infected or uninfected with nematode to certain extent. It is clear that all of the tested essential oils significantly improved growth of the uninfected tomato plant parameters as compared with those of the infected ones except that of fresh and dry weight of shoot (Table 2).

As for the infected plants, castor oil significantly increased length and fresh weight of shoot when compared with the other treatments tested or nematode alone. The same trend was observed with respect to the uninfected plants. Among all tested materials, castor oil showed the highest increment in fresh weight of the whole plant either infected or uninfected with values of 135.42% and 217.59%, respectively. Castor oil also ranked first in increasing shoot dry weight of the healthy tomato plants with value of 37.14% whereas recorded the second to linseed oil treatment with the infected plants with values of 32.56% and 35.2%, respectively. Moreover, sesame oil achieved the second values to castor oil treatment in increase percentage of both fresh weight of whole plant (132%) as well as shoot dry weight (29.24%), respectively.

As a whole, growth of the uninfected tomato plants which received sesame, castor and linseed oils were significantly affected as compared with those of infected plants. On the other hand, no significant differences were noticed among infected and uninfected plants when treated with garlic, neem and chamomile oils.

Data presented in table (3) show reduction percentage of population densities in soil and root; and number of galls and egg-masses on tomato roots.

Table (3): Development and reproduction of *Meloidogyne incognita* infecting tomato seedlings as influenced by the addition of six essential oils to MS medium then transplanted to sterilized soil under greenhouse conditions.

Treatments	Nematode population in			Total	Red. %	No. of Galls	Red. %	RGI	No. of Egg masses	Red. %	EI
	Soil/ pot	Root									
		Develop. stages	Females								
Garlic oil+ N	375 b	46.3 b	97.3 a	518.6 b	75.97	60 c	70	4.0	0.0 b	100	0.0
Sesame oil+ N	300 bc	14.3 c	28.3 b	342.6 bcd	84.13	20 d	90	3.0	0.0 b	100	0.0
Neem oil+ N	225 bcd	36.3 bc	89.3 a	350.6 bc	83.76	87 b	56.5	4.0	0.0 b	100	0.0
Castor oil+ N	74.3 d	11.6 c	53.6 ab	139.6 d	93.53	30 d	85	3.0	0.0 b	100	0.0
Chamomile oil+ N	150 cd	25.3 bc	70.3 a	245.6 cd	88.62	25 d	87.5	3.0	0.0 b	100	0.0
Linseed oil+ N	74.3 d	18 c	65 a	157.3 cd	92.71	25 d	87.5	3.0	13 a	97.4	3.0
N alone	1200 a	904 a	54.3 ab	2158.3a	----	200 a	----	5.0	114 a	----	5.0

***Each figure represents the mean of three replicates.**

***Means in each column followed by the same letter did not differ at P< 0.05 according to Duncan's multiple range test.**

N= 1500 *M. incognita* J_2

It is evident that final nematode population was significantly affected by all tested oils as compared with nematode alone. Application of castor oil treatment caused the highest reduction percentage in nematode population that amounted to 93.53% followed by linseed oil application with value of 92.71%. The lowest reduction percentage was achieved from plants received garlic oil with value of 75.97%.

Concerning root galling, a significant reduction in number of galls on tomato roots was achieved with root gall indices ranged from 3 to 5 (Table 3). Among all tested essential oils, sesame oil significantly decreased number of galls on tomato roots with reduction percentage of 90%, followed by those treated with either chamomile or linseed oils with value of 87.5% each.

Regarding egg-masses numbers, *M. incognita* did not reproduce on plants treated with all of the tested materials except those received linseed oil with reduction percentage value of 97.4%.

Obviously, the percentage increase of fresh weights of whole plant as well as shoot dry weights in the infected plants over those of the uninfected ones was resulted due to the exist tolerance of tomato plants to nematode infection that expressed by the presence of the tested essential oils within the artificial medium. Moreover, all tested materials showed reduction percentage of final *M. incognita* population density with values ranged from 75.97 to 93.53% as well as 97.4 to 100% for egg-masses number but no nematode reproduction occurred on tomato roots received sesame, garlic, neem, castor and chamomile oils except that of linseed oil with 13 egg masses/root.

Data in table (4) showed host category of tomato cv Strain-B as influenced by MS medium supplemented with six essential oils, then transplanted to sterilized sandy loam soil (1:1) in pots infected with *M. incognita* under greenhouse conditions. Results revealed that none of treated tomato plants were immune to *M. incognita*, since galls and varying numbers of nematode developmental stages were recorded infecting their root systems depending on their degree of resistance.

Table (4): Impact of *Meloidogyne incognita* infection on tomato plant cv Strain-B host suitability as influenced by the addition of six essential oils to MS medium then transplanted to sterilized soil under greenhouse conditions.

Treatments	Final nematode population (p_f)	*R Factor (P_f/P_i)	*RGI	**EI	●Host category
Garlic oil+ N	518.6 b	0.35	4	0.0	*SR **HR
Sesame oil+ N	342.6 bcd	0.23	3	0.0	VR HR
Neem oil+ N	350.6 bc	0.23	4	0.0	SR HR
Castor oil+ N	139.6 d	0.09	3	0.0	VR HR
Chamomile oil+ N	245.6 cd	0.16	3	0.0	VR HR
Linseed oil+ N	157.3 cd	0.10	3	3	VR VR
N alone	2158.3 a	1.44	5	5	S S

●Host category based on: *Root gall index (RGI) or **Egg-mass index according to Hadisoeganda& Sasser (1982). S= susceptible, SR= slightly resistant, VR= very resistant, MR= moderately resistant and HR= highly resistant.

***R factor = Final population / Initial population**

According to the scale given by Hadisoeganda& Sasser (1982) based on egg-mass index, the tomato host plants treated with the essential oils i.e. garlic or sesame or neem or castor or chamomile were rated as highly resistant, their egg-masses indices were recorded to be zero for each. On the other hand, plants treated with either linseed oil or none were classified as very resistant or susceptible plants since they gained egg-mass indices of 3 or 5, respectively.

Degree of resistance based on either egg-mass index or root gall index according to Hadisoeganda& Sasser (1982) was not the same for most treated tomato plants. The exception was found with plant treated with linseed oil which was rated as very resistant to *M. incognita* based on egg-mass and root gall indices criteria, with values of 3 and 3, respectively. On the other hand, plants treated with sesame, castor, chamomile and linseed essential oils were classified as very resistant with values of 3, 3, 3 and 3 for their root gall indices, while those of garlic and neem oils were considered to be slightly resistant with values of 4 and 4 of root gall indices, respectively (Table 4).

Results from the present inplanta experiment indicated that tested essential oils directly affect nematode reproduction as recorded by other phytochemical compounds (Perez *et al.*, 2003) who reported that the essential oil of *Chrysanthemum coronarium* and organic amendments from Asteraceae species may serve as nematicides.

In the present study, essential oils of castor and sesame showed the highest nematicidal properties against the target nematode, *M. incognita* infecting tomato. The nematicidal activity of such essential oils could be attributed to the richness of essential fatty acids; oleic acid (6, 43.5%); linoleic acid (5, 42%); palmitic acid (1, 8%), respectively. In addition, the essential oil of castor contains ricinoleic acid, 85%; linolenic acid, 1%; Dihydroxystearic acid 0.5% and ricin. On the other hand, sesame oil constituting myristin, sesamolin and the antioxidant sesamine (sesamal) where linoleic acid was isolated as a nematicidal principle (Anke, 1995). Moreover, sesame oils exhibits also insecticidal (Thabet,1999), antifungal and antibacterial properties, sesame oils are easily biodegraded and broken down into products that aren't harmful to human, animals or to the environment. The mode of action of fixed or essential oils against nematode is not clear. In insects several essential oils inhibit acetylcholinestras activity (Ryan and Byrne, 1998). Essential oil may disrupt the cell membrane of the nematode and change its permeability (Oka *et al.*, 2000). Since essential oils have been reported to have fungicidal, antibacterial and nematicidal activities, soil treatment with the botanical pesticide oil could serve as a soil disinfectant.

Apparently, the importance of using plant tissue culture technology in this paper due to the need of large number propagation of tomato plant in a short time, the addition of essential oil traces to such artificial medium where seeds germination took place in order to produce healthful tolerant, resistant or less susceptible seedlings against the infection of *M. incognita* under greenhouse conditions. Obviously, results of this investigation indicated the possible use of these traces at low cost to MS medium of plant tissue culture will avoid the pollution of 60% of the cultivated Egyptian soil (heavy soil)

which prevent the nematicidal activities of such essential oils or products when added directly to such soil against *M. incognita* infecting any economic plant. In conclusion, more researches are needed on this respect before recommend it for IPM program against plant parasitic nematodes.

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كفاءة بعض الزيوت الطيارة المضافة الي بيئة النمو (موراشيج وسكوج)علي ملائمة جذور نباتات الطماطم للاصابة بنيماتودا تعقد الجذور (ميلويدوجين انكوجنيتا) تحت ظروف الصوبة.

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وحدة بحوث النيماتولوجي- قسم الحيوان الزراعي- كلية الزراعة- جامعة المنصورة- مصر.

تم دراسة تأثير ستة أنواع من الزيوت النباتية هي: الثوم والسمسم والنيم والخروع والبابوننج والكتان المضافة بنسبة ٠,١% الي بيئة صناعية معقمة (موراشيج واسكوج) لنمو شتلات الطماطم صنف سترين بي قبل نقلها كشتلات الي اصص بلاستيكية تحتوي علي تربة معقمة (١:١) وذلك علي الاصابة بنيماتودا تعقد الجذور (ميلويدوجين انكوجنيتا) تحت ظروف الصوبة الزجاجية ٣٠±٥° م. اوضحت النتائج أن جميع الزيوت المستخدمة أدت الي حماية وتحسين نمو نباتات الطماطم سواء المصابة او غير المصابة بالنيماتودا لدرجة معينة. من بين كل الزيوت المختبرة أعطي زيت الخروع أعلي زيادة في الوزن الرطب للنباتات سواء كانت مصابة أو غير مصابة بنسب ١٣٥,٤٢% و٢١٧,٥٩% علي التوالي. أعطي أيضاً زيت الخروع أفضل النتائج في زيادة الوزن الجاف للمجموع الخضري بالنسبة للنباتات السليمة (٣٧,١٤%) بينما جاء في المرتبة الثانية بعد زيت الكتان بالنسبة للنباتات المصابة بقيم ٣٢,٥٦% و٣٥,٢% علي التوالي.

جاءت المعاملة بزيت السمسم في المرتبة الثانية بعد زيت الخروع في زيادة كل من الوزن الكلي الرطب والوزن الجاف للمجموع الخضري بنسب ١٣٢% و٢٩,٢٤% علي التوالي. تم ملاحظة أعلي انخفاض في تعداد النيماتودا من المعاملة بزيت الخروع حيث كانت نسبة الانخفاض ٩٣,٥٣% يليها الكتان بنسبة ٩٢,٧١% بينما أدت المعاملة بزيت السمسم الي خفض أعداد العقد النيماتودية علي جذور الطماطم بنسبة ٩٠% يليها في ذلك المعاملة بزيت البابوننج والكتان بنسبة خفض ٨٧,٥% لكل منهما. لم تتمكن نيماتودا تعقد الجذور من انتاج كتل بيض علي جذور النباتات المعاملة بكل الزيوت وتعتبر في هذه الحالة نباتات عالية المقاومة بالرجوع الي مؤشر كتل البيض (صفر لكل منها) بينما النباتات المعاملة بزيت الكتان تعتبر مقاومة جداً حيث كانت قيمة مؤشر كتل البيض ٣ وكانت نسبة الخفض في أعداد كتل البيض ٩٧,٤%.

* هذا البحث مستخلص من رسالة الدكتوراه للباحث الاول.