Efficiency of Certain Nematicides against Root-Knot Nematodes *Meloidogyne incognita* on Tomato Plants under Laboratory and Greenhouse Conditions

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ABSTRACT

The effect of five nematicides {Tervigo 2% SC (abamectin), Dento 40% EC (fenamiphos), Dina Tox 20% EW (fosthiazate), Vydate 24% SL (oxamyl) and Velum Prime 40% SC (fluopyram)},for the control of *Meloidogyne incognita* infected tomato plants (cv. Carioca) was evaluated under the laboratory and greenhouse conditions on tomato plants. In laboratory tests, the LC_{50} of the tested compounds were 05.39, 12.73, 8.61, 09.53 and 03.47 mg l^{-1}(mg l-1), respectively. Also, fluopyram and abamectin were the most effective in the inhibition of egg hatching which gave LC_{50} values were 02.23 and 01.96 mg l^{-1}, respectively. Moreover, among all the tested nematicides, abamectin was the only nematicide which had irreversible inhibition to J_2 motility, while the nematode which exposed to other nematicides recovered their motility after 1 and 24 hrs from exposure. The egg differentiation showed that, fluopyram and abamectin were the most effective in the reduction% of egg differentiation in laboratory studies. Under greenhouse conditions, all tested nematicides were reduced galls formation and other nematode criteria and increased tomato plant growth compared to untreated control. The obtained results show that abamectin was the least nematicide in controlling of nematode infection as soil drenching treatment in greenhouse pots experiment, while it has been strong nematicidal activity on J_2 and egg hatching of nematodes in laboratory studies.

Keywards: Nematicides; Differentiation; Tomato plants.

INTRODUCTION

Tomato crop (*Solanum Lycopersicum* L. = *Lycopersicum esculentum* Mill.) is one of the most consumed vegetables in Egypt and the rest of the globe (Abd El- Ghany, 2011 and Saad *et al*., 2017). Tomato production is split between fresh market and industrial processing, both of which are highly significant from an economic standpoint (Silva *et al*., 2019). In Egypt, the total area under cultivation for the tomato crop was up to 170,862 acres, and the estimated annual production was 6.8 million metric tons (FAOSTAT, 2020).

Root-knot nematode (RKN) of the genus *Meloidogyne*, is one of the main pests that attack several crops to their worldwide. (Jones *et al*., 2013; Wram and Zasada, 2019). *Meloidogyne incognita* is the most significant species in the genus Meloidogyne due to its aggression and global distribution (Sikora and Fernandez, 2005). Moreover, cooperate with other microorganisms causing the complex diseases in tomato (Tian *et al*., 2015). The infected plants by *M. incognita* suffer severe harm by formation of galls on roots, as well as from distorted roots that limit nutrient and water intake and impair plant growth and productivity (McCarter, 2008 and Kepenekci *et al*., 2016). The damage globally estimated yield losses of tomato plants duo to root-knot nematodes were reached up to 27% and more (Sharma and Sharma, 2015). The infestations of RKN on tomato plants are a significant economic problem in Egypt as well, particularly in sand soil and reclaimed desert lands where high crop damage results. The *Meloidogyne* species are the real threat almost all vegetable crops and are becoming a limiting factor in crop production (Ibrahim *et al*, 2010 and Ibrahim 2011).

So, to manage the *M. incognita* nematode, several methods were recorded to control such as plant resistance, trap crops, organic amendments, biological control agents (BCAs) can be used. However, chemical control is considered one of the most effective and reliable including fumigants and nonfumigants nematicides (Zasada *et al*., 2010). The fumigant nematicides can be highly efficacious against nematodes, but they are costly, require specialized application equipment and buffer zones, highly volatile, require long periods after application to avoid the phytotoxicity and environmentally restricted (Morris *et al*., 2016). The non-fumigant nematicides include organo-phosphates like fosthiazate, fenamiphos and carbamates like oxamyl (Zasada *et al*., 2010). Both organophosphates and carbamates act as acetyl cholinesterase inhibitors, which leads to nematode paralysis (Chitwood, 2003 and IRAC, 2015). In Egypt, fluopyram is registered

as a nematicide and became available at the end of 2020 (Massoud *et al*., 2021). Fluopyram belong to pyridinyl-ethyl-benzamide chemical group and rapidly kills nematodes by acting as a succinate dehydrogenase inhibitor (Burns *et al*., 2015). It has low mammalian toxicity, is ecofriendly, and proposed for using in production of vegetables. Also, abamectin was registered during the last few years in Egypt as a nematicide. Additionally, several reports recorded that abamectin has nematicidal action against root-knot nematodes and other genus of plant parasitic nematodes infecting different crops (Saad *et al*., 2012; El-Nagdi *et al*., 2015 and Radwan *et al*., 2019).

Therefore, the objectives of this study were tested the toxicity of five nematicides on second-stage juveniles (J_2) of PPNs (*M. incognita*) in laboratory and, study the effect of tested nematicides on egg hatching, egg differentiation and estimating the reversible effect of nematicides. Greenhouse pot experiments include, evaluate the tested nematicides at the recommended rate of application against nematode infection and the effect on reproduction of tomato roots and the effect on tomato plant growth.

MATERIALS AND METHODS

Tomato crop (*Solanum Lycopersicum* L. = *Lycopersicum esculentum* Mill.) (cv. Carioca) were supplied by (Shoura Company). The soil used in this study was from Ashmoun City, Menofia Governorate. Some physical and chemical characteristics are listed in Table (1). Five commercial formulations of nematicides (Table, 2). The nematode inoculum of *M. incognita* was prepared according to Whitehead and Hemming (1965) and Hartman and Sasser (1985), and the identified nematode was according to Taylor and Nelscher (1974) and Saad *et al*., (2017) using a stereo-microscope in the laboratory.

Laboratory experiments.

Toxicity of nematicides to J_2 of root-knot nematodes.

To evaluate the toxicity of the five tested compounds (Table, 2) on newly hatched second-stage juveniles (J_2) under laboratory conditions (25± 2 ^{0}C and 65%±5 R.H, photoperiod (D: L). 12: 12h) after 24, 48 and 72 hrs after exposure were recorded. Different serial concentrations from each compound were prepared. These concentrations were 0.0, 1.0, 3.0, 5.0, 7.0, 10.0, 20.0 and 50.0 mg l-1 . The suspension of newly hatched J_2 was prepared. The mean number of 2 nd stage juveniles (J_2) in the suspension of 1ml (100 juvenile) was added to 1ml of each concentration from each of the examined compounds. Three replicates for each concentration were used in each treatment and the control treatment consisted of the sterilized distilled water (SDW). The second-stage juveniles showing motionless straight posture after prodding were considered dead (Ishibashi and Takii, 1993). Mortality was observed with the aid of a light microscope and calculated. The obtained data were expressed as toxicity lines, thus, LC_{50}, LC_{90} and slope values were recorded by log-probit software program Ldp Line® model "Ehabsoft" (Bakr, 2000) and according to (Finney, 1971). Also, the Toxicity Index (T.I.) by Sun (1950) was recorded as follow:-

Toxicity index (T.I.) = LC_{50} of the most effective compound/ LC_{50} of the tested compound × 100, and Relative Potency (R.P.) was recorded according to El- Sheikh and Aamir (2011) as follow: - (R.P.) = LC_{50} of the tested compound / LC_{50} of the most effective compound.

Effect of nematicides on nematode egg hatching.

To study the effect of treatments on egg hatching of *M. incognita* at concentrations of 0.0, 0.5, 1.0, 5.0, 10.0, 20.0, 50.0 and 100 mg l-1 with three replicates for each concentration from each nematicide. Egg masses submerged in clean sterilized distilled water (SDW) served as the control. The petri dishes (3cm) were kept for 3 days in an incubator at 25 ± 2 C°. Egg masses of uniform color (light brown) and placed in petri dishes (3 cm diameter). Each petri dish was filled with approximately 10 egg masses, in addition to 1 ml of each concentration of the tested nematicides. Numbers of newly hatched juveniles were counted using a research microscope (× 100 magnification) after 3 days of treatment. The hatching inhibition percentage was calculated according to the following equation:

Egg hatching inhibition (%) = C- T / C× 100. by El-Ashry *et al*., (2021).

Where: - C and T names the No. of egg hatched in control and treatment, respectively.

Estimation the reversible effect of nematicides.

The average number of second stage juveniles (J_2) in 1 ml suspension (100 juvenile) was added to 1 ml of each concentration of the compounds examined, three replicates were used for each concentration and the control treatment consisted of sterilized distilled water (SDW) only. After the 1-hrs from exposure to

these concentrations, the nematode was examined to see the obvious paralysis of individuals, and then after that nematodes were carefully rinsed twice on a 25-µm-pore sieve with sterilized distilled water (SDW), then, transferred to a counting dish containing sterilized distilled water (SDW). Motile and immotile nematodes were determined using a light microscope after 1, 24 hrs of rinsing and washing with distilled water. Nematodes were considered immotile if they did not respond to being touched by a small probe and the percentage of immotile and motile nematodes was calculated.

Effect of nematicides on egg differentiation.

The effect of treatments (at the concentrations of 0.0, 1.0, 10.0, and 50 mg l-1) on egg differentiation was performed according to a method described by Giannakou and Kamaras (2021). The quantification of egg suspension was done using a light microscope (100×), and eggs were used directly for the bioassays after adjusting the number of eggs per ml to about 200±10 of eggs suspension. Each petri dish (3 cm diameter) was filled with approximately 200 eggs (1ml of eggs suspension) and added to 1 ml of each concentration from each nematicides. Three replicates were used for each concentration and the control treatment consisted of sterilized distilled water (SDW). After immersion of eggs, all treatments were left under room temperature (25±2°C) for 18 days. The eggs was examined to see to find differentiation or undifferentiation. Where, those eggs with cell division (one, two, or more cells) were considered undifferentiated, while those with a fully developed juvenile were considered differentiated. The reduction% was calculated according to the following equation: Reduction in differentiation (%) = C-T/C×100

Where: - C and T names =No. of differentiation in control and treatments, respectively.

Greenhouse pot experiments.

To study the efficiency of the tested compounds on nematode infection (*M. incognita)* and their effects on growth parameters of tomato plants (cv. Carioca). The experiments were performed in pots greenhouse of in the Department of Plant Protection, Faculty of Agriculture (Cairo), Al-Azhar University. Clay pots (15.0 cm in diam.) were surface sterilized by 5% formalin solution and left for 7 days before the beginning of experiments. The used soils were air dried and sieved through a (2mm screen). Soil was packed in plastic bags and steamed in an autoclave until a temperature of 100- 110 °C (1.3 to 1.4 Lb pressure) was reach and then holding the temperature at 90 – 110 °C (1.1 to 1.4 Lb pressure) for one hour according to a method described by Knudsen and Bin (1990). Each pot contain (1kg soil) and 4 pots were used for each treatment including the untreated control. Tomato seedlings (10 cm in hight) were transplanting in to the pots (plant per pot). After 7 days from transplanting, each pot were inoculated with 1200 newly hatched J_2 of *M. incognita* per plant. The second-stage juveniles (J_2) were added by pipetting 2 ml of the inoculum suspension into three holes around the root system. After inoculation, the holes were covered with moist soil. The tervigo® nematicide was applied instantly after *M. incognita* inoculation according to the recommended rate as soil drenching (Table, 2). Systemic nematicides were applied, after 3 days at the recommended rates, from the nematode inoculation. Sterilized infested and sterilized non infested soil were served as control. All pots were, arranged in a Complete Randomized Block Design (RCBD) and kept in the greenhouse (30±5°C). The normal agricultural practices were used. After 45 days from nematode inoculation, plants were gently removed from pots and all nematode parameters (number of galls and egg masses per root system, the number of 2nd juveniles per pot and average number of eggs egg masses^{-1}) were counted according to (Hussey and Barker, 1973). Nematode final population, nematode reproduction, percentage of nematode penetration and percentage of nematicidal efficacy was also calculated according to Norton (1978) as follow: Rf =Pf/Pi

Where: - *Pi* = nematode initial inoculum, *Pf* = nematode final population.

Nematicide efficiency % = control (Rf) – treatment (Rf)/ control (Rf) × 100

The length (cm) and fresh weight (gm) of shoot and root (Plant growth criteria) were recorded by the following equation: -

% increase of growth parameter (G.P) = T – C/ C × 100

Where: -T= G. P in treatmentC = G. P in infected control

Statistical analysis.

All data were subjected to (ANOVA) by using Costat program (1988) and significant difference among the treatments was portioned by Duncan's(1955) multiple range

test and /or LSD test at probability levels of $P = 0.05$. The toxicity lines were draw and the LC_{50} or EC_{50} values were estimated using log-probit software program Ldp Line® model "Ehabsoft" (Bakr, 2000 and Finney, 1971).

RESULTS AND DISCUSSION

Laboratory experiments.

Toxicity of nematicides to J_2 of root-knot nematodes.

Laboratory experiments were conducted to evaluate the toxicity of the tested nematicides to J_2 of root-knot nematode after 24, 48 and 72 hrs for exposure time. The results of Table (3) showed that, all tested nematicides exhibited a clear nematicidal activity on J_2 of nematodes. Based on the LC_{50} values the order of the nematicidal toxicity of the nematicides in descending order were fluopyram > abamectin > fosthiazate > oxamyl > fenamiphos. Specifically. Fluopyram exhibited the highest rates of J_2 mortality with LC_{50} values 04.20, 03.47 and 02.44 mg l^{-1} after 24, 48 and 72 hrs of exposure, respectively, followed by abamectin with 7.19, 5.39 and 4.89 mg l^{-1} of LC_{50} values after 24, 48 and 72 hrs of exposure. On other hand, fenamiphos was the least toxicity with LC_{50} values 14.9, 12.7 and 10.41 after 24, 48 and 72 hrs of exposure, respectively. The relative potency and toxicity index were calculated.

Effect of nematicides on nematode egg hatching.

Data in Table (5) showed the effect of nematicides on egg hatching of root-knot nematodes. Based on EC_{50} values (effective concentration that inhibit 50% of nematode egg hatching), abamectin and fluopyram were the most effective nematicides in egg hatching inhibition by EC_{50} values, of 01.96 and 02.23 mg l^{-1} , respectively. On contrast, fosthiazate and oxamyl showed a weak inhibition of nematode egg hatching with EC_{50} values 09.59 and 07.84 mg l^{-1}, respectively. Fenamiphos gave EC_{50} of 06.73 mg l^{-1}.

Estimation the reversible effect of nematicides.

The percent recovery in J_2 motility was calculated when removed from the suspension of two concentrations (LC_{15} and LC_{50}) of tested nematicides after two time of exposure (1 and 24 hrs) and exposed in sterilized distilled water(SDW). The data in Table (6) showed that, the rate of nematode recovery was decreased with increase the concentration and exposure time. Also, the highest recovery % was achieved after the nematode exposed to fosthiazate treatments at LC_{15} by 94.07 and 88.21%, for 1 and 24 hrs of time exposure, respectively. On other hand, the data indicated that abamectin at both concentrations had irreversible inhibition of nematode motility and the nematode recovery was very negligible by 3.01 and 4.49 %, for 1 and 24 hrs of exposure with the least concentration of the nematicide. The nematodes which exposed to the other nematicides were recovered a higher percentage of movement by the following descending order: - fenamiphos > oxamyl>fluopyram.

Effect of nematicides on egg differentiation.

The laboratory experiments was conducted to examine the effect of nematicides on egg differentiation (development of nematode from embryogenic stages to fully developed juvenile within the egg). The obtained results (Table, 7) show that, in general, all nematicides at any concentrations (1, 10 and 50 mg l^{-1}) significantly inhibited egg differentiation compared with untreated control. Also, a drastic decrease of egg differentiation was observed when the concentration was increased to 10.0 and 50.0 mg l^{-1}. The fluopyram and abamectin treatments at 50 mg l^{-1} showed the higher inhibition rates in egg differentiation by 95.68 and 91.89%, respectively. Moreover, no significant difference was observed in inhibition of egg differentiation between the treatments of abamectin at 1.0 and 10.0 mg l^{-1}. On the other hand, the least effective in egg differentiation inhibition was observed with fosthiazate at 1mg l^{-1} and oxamyl at 1.0 and 10.0 mg l^{-1} by 8.11, 12.97 and 23.78, respectively. Also, fenamiphos caused moderate reduction of egg differentiation and this effect gradually increase by increasing their concentrations.

Greenhouse experiment.

The efficiency of five nematicides (applied at the recommended concentrations as soil drench after infection) were evaluated against *M. incognita* on tomato plants as recorded. The results in (Table, 8), showed that, all treatments significantly, reduced the nematode criteria (number of galls $root^{-1}$, number of egg masses $root^{-1}$, eggs $eggmass^{-1}$, number of developmental stages within root and number of nematode J_2 in soil) comparing with the untreated control. Fluopyram achieved the greatest reduction in galls numbers and reproduction rate (Rf) of root-knot nematode on tomato roots and in the soil. However, abamectin has been strong nematicidal activity *in vitro* assays (Tables, 3 and 5), it was the least nematicide in controlling of nematode as soil

drenching treatments in greenhouse assay (Table, 8). At the same time, the treatment with fosthiazate, oxamyl and fenamiphos showed a significant reduction of root galling (No. of galls root^{-1} was 47, 64 and 97.00, respectively) and rate of nematode reproduction (Rf) was 01.62, 01.92 and 02.73, respectively.

The effect of nematicides on plant growth parameters of tomato plants indicated that, all treatments in Table (9), enhanced weight of tomato shoot and root compared with untreated inoculated control except with the abamectin treatment.

The present study investigated the different nematicidal activities of five non-fumigant nematicides belong to different chemical groups (pyridinyl-ethyl-benzamide (fluopyram), organophosphate (fenamiphos and fosthiazate), carbamate (oxamyl) and avermectin (abamectin) on root-knot nematodes under laboratory and greenhouse pot experiments. Our results in this study demonstrated that, all the tested nematicides achieved nematicidal activity against root-knot nematodes in the laboratory and greenhouse assays. These results are in consistent with previous findings (Raddy *et al*., 2013; Saad *et al*., 2017; Khalil and Alqadasi, 2019; Silva *et al*., 2019; Qing Li *et al*., 2020; Stuky and Dahlin, 2022 and Khalil *et al.,* 2022). Additionally, in greenhouse studies, fluopyram showed the highest efficiency in reducing nematode infection. These results were in agreement with those obtained by Yue *et al.* (2020). They reported that fluopyram caused the greatest inhibition of nematode galls formation in tomato roots when compared with abamectin and fosthiazate in a greenhouse experiment. Also, it was found that, the efficacy of fluopyram in soil was superior compared with oxamyl (Giannakou and Kamaras, 2021). Fluopyram can effectively reduce the number of root-knot nematode, root-galling and promote the growth of tomato in greenhouse conditions (Li, *et al*., 2020 and Qing Li *et al*., 2020).

It was be accepted that carbamate and organophosphate nematicides acted by the inhibition of acetylcholinesterase (ACHE) at cholinergic synapses in the nematode nervous system, that Inhibition was most likely explanation for the observed effect of organophosphate and carbamate nematicides on the orientation behavior, paralyze and ability of root invasion of nematodes (Wright, 1981; Opperman and Chang, 1990). Also, it is known that the nematicidal potential of abamectin is attributed to it is stimulating the release and binding of γ- aminobutyric acid (GABA) at nerve ending. This causes an influx of chloride ion into the cells and lead to hyper polarization and subsequent paralysis of neuromuscular systems (Cully *et al.,* 1994; Burkhart, 2000 and Bloomquist, 2003). Furthermore, it was reported that fluopyram had a known mode of action which was a succinate dehydrogenase inhibitor (SDHI) through the mitochondrial blocking of electron transport in tricarboxylic acid cycle and oxidative phosphorylation metabolic pathways, consequently exposed nematode larvae rapid lose their energy source, which causes the body to be liner (Faske and Hurd, 2015; Hua *et al.,* 2020 and Yue *et al.,* 2020).

According to our results in this study, it was clear that abamectin and fluopyram showed the highest inhibition of egg hatching and egg differentiation. These results are consistent with previous findings by Yue *et al.,* (2020). They found that, abamectin significantly inhibited egg hatching comparing with other tested nematicides. Although the eggshell of nematode can protect the eggs from external toxic chemicals, the permeability of eggshell may have changed just before hatching process to allow some martials to pass into eggs through the eggshell (Curtis *et al.,* 2009). Therefore, the inhibition of egg hatching by abamectin may be attributed to the ability of their molecules to cross the eggshell directly before hatching and the normal of J_2 hatching is disrupting. This effect was observed in plant parasitic nematodes which exposed to other biogenic materials. Further researches may be interested to determine the possible reason for unhatched J_2 are more susceptible to biogenic nematicides, because these chemicals have more ability to cross the eggshell (Masler, 2008). Furthermore, it was found that fluopyram has inhibitory effect to egg differentiation and hatching. These results are supported the previous findings by Giannakou and Kamaras, (2021).Who reported that, fluopyram inhibited the egg hatching of nematode and ceased eggs differentiation at the least concentration (4.00 mg l^{-1}), whereas oxamyl did not inhibit hatching at all concentrations used (4.00, 16.00, 32.00, 64.00 mg l^{-1}). Additionally, this could be due to the fluopyram solution seems too able to enter the gelatinous matrix of egg mass and act on the egg.

From our results in this study, it was noticed that abamectin was the only nematicide which had irreversible inhibition of J_2 motility, and nematode recovery was very

negligible. These results are in agreement with those obtained by Faske and Starr (2006). Who found that, the paralysis and the mortality of nematode J_2 which exposed to abamectin were irreversible and increased after removal it from the nematicide. Moreover, we observed that, the body nematode form was rigid and straight when treated with abamectin nematicide, and not responded to being pricked by a small needle. Abamectin is one of the only non-fumigant nematicides that are truly nematicidal as its impact on nematode paralysis is irreversible (Faske and Starr, 2006). In another study showed that, the treatment with abamectin nematicide resulted in irreversible paralysis of nematode J_2 and abamectin had very good nematicide potential, better than that of organophosphate nematicides (Qiao *et al*., 2012). On other hand, reversible effects observed for root-knot nematode $J_2$to aldicarb (oxime carbamate nematicide) and the same effect have been reported in other plant-parasitic and free-living nematodes which exposed to the same nematicide (Nelmes, 1970; Opperman and Chang, 1991). On other hand, Faske and Hurd (2015) found that nematode paralysis was reversible with over 54% recovery in motility within a 24-hrs period after removal from the fluopyram solution for both *M. incognita* and *R. reniformis*. This reversible effect indicates fluopyram is nematistatic, which is similar to other non-fumigant nematicides.

The obtained results in the study showed that, abamectin was the least nematicide in controlling of nematode infection as soil drenching treatment in greenhouse pot experiments, while it has been strong nematicidal activity on J_2 and egg hatching of nematodes in laboratory studies. This finding is in agreement with the results by Li *et al*. (2020). They reported that abamectin showed higher toxicity action against J_2 of nematode than fluopyram, the control effect of abamectin was significantly lower than that of fluopyram in both pots and field trials. Possible reasons have been suggested to explain these differences such as abamectin undergoes photo degradation; has a high ability to adsorption on the soil particles, low mobility and diffusivity in the soil, low solubility in water and has a short half-life in soil (Hally *et al*., 1993; Dioniso and Rath, 2016).

From these results in this study, it was concluded that, most of the tested five nematicides showed nematicidal activity against root-knot nematode in laboratory and in greenhouse pot experiments, but to varying degrees. However, abamectin had strong nematicidal action on J_2 and eggs in laboratory, it was weak in controlling nematode infection when applied directly in soil after nematode infection. The new nematicide fluopyram is promising nematicide in nematode management.

REFERENCES

Abd El-Ghany, N.M. 2011: Molecular evaluation of *Bacillus thuringiensis* isolates from the soil and production of transgenic tomato plants harboring Bt gene for controlling lepidopterous insects in Egypt. Dissertation, Ain Shams University, Egypt, pp 270.

Anonymous, 2011: The Pesticide manual. Published by the British Crop Protection Council.

Bakr, E. 2000: LdP Line. [http://www.ehabsoft.com/ldpline/].

Bloomquist, J.R. 2003: Chloride channels as tools for developing selectiveinsecticides. Arch. Insect. Biochem. Physiol. 54: 145-156.

Burkhart, C.N. 2000: Ivermectin: an assessment of its pharmacology, microbiologyand safety. Vet. Hum. Toxicol. 42: 30-35.

Burns, A.R., Luciani, G.M., Musso, G., Bagg, R., Yeo, M., Zhang, Y., Roy, P.J. 2015: Caenorhabditis elegans is a useful model for anthelmintic discovery. Nature Communications, 6(1): 74-85.

Costat software. 1988: Microcomputer program analysis, CoHort software, Berkely, CA, USA.

Cayrol, J.C., Dijan, C., Frankowski, J.P. 1993: Efficacy of abamectin B1 for the control of *Meloidogyne arenaria*. Fundamentals of Applied Nematology 16:239–46.

Cully, D.F., Vassilatis, D.K., Liu, K.K., Paress, P.S., Van der Ploeg, L.H., Schaeffer, J.M., Arena, J.P. 1994: Cloning of an avermectin-sensitive glutamategated chloridechannel from *Caenorhabditis elegans*. Nat. 371: 707-711.

Chitwood, D.J. 2003: Nematicides. In: Plimmer, J.R. (Ed.), Encyclopedia of Agrochemicals, vol. 3. John Wiley and Sons, New York, pp. 1104-1115.

Curtis, R.H.C., Robinson, A.F., Perry, R.N. 2009: Hatch and host location. In R. N. Perry, M. Moens, & F. J. Starr (Eds.), Root-knot nematodes (pp. 139–162). Wallingford, UK: CABI Publishing.

Duncan, D.B. 1955: Multiple range and multiple F. tests. Biometrics. 11: 1-42.

Dionisio, A.C., Rath, S. 2016: Abamectin in soils: analytical methods, kinetics, sorption and dissipation. Chemosphere 151:17–29.

El-Ashry, R.M., Ali, M.A., Elsobki, A.E., Aioub, A.A. 2021: Integrated management of *Meloidogyne incognita* on tomato using

combinations of abamectin, *Purpureocillium lilacinum, rhizobacteria,* and botanicals compared with nematicide. Egyptian Journal of Biological Pest Control, 31(1): 1-10.

El-Nagdi, W.M.A., Hafez, O.M., Saleh, M.A. 2015: Impact of a biocide abamectin for controlling of plant parasitic nematodes, productivity and fruit quality of some date palm cultivars. Sci. Agric. 11 (1): 20-25.

El-Shekh, E.S.A., Aamir, M.M. 2011: Comparative effectiveness and field persistence of insect growth regulators on a field strain of the cotton leafworm, *Spodoptera littoralis*, Bosid (Lepidoptera: Noctuidae). Crop Protection, Vol. 30(6): p. 645-650.

FAOSTAT. (2020). https://www.fao.org/faostat/en/#data/QCL/visualize.

Faske, T.R., Hurd, K. 2015: Sensitivity of *Meloidogyne incognita* and *Rotylenchulus reniformis* to fluopyram. Journal of Nematology 47:3 16–21.

Faske, T.R., Starr, J.L. 2006: Sensitivity of *Meloidogyne incognita* and *Rotylenchulus reniformis* to abamectin. Journal of Nematology 38:240–244.

Finney, D.J. 1971: Probit Analysis (3rd edition). Cambridge University Press, Cambridge,UK. ISBN 0-521-08041-X. OCLC 174198382.

Giannakou, I.O., Kamaras, S. 2021: Comparison of a Vintage and a Recently Released Nematicide for the Control of Root-Knot Nematodes and Side Effects on Two Entomopathogenic Nematodes. Plants, 10(8): 1491.

Halley, B.A., Vanden Heuvel, W.J.A., Wislocki, P.G. 1993: Environmental effects of the usage of avermectins in livestock. Veterinary Parasitology 48:109–25.

Hartman, K.M., Sasser, J.N. 1985: Identification of *Meloidogyne* species on the basisof differential host test and perineal pattern morphology. In: An advanced treatiseon *Meloidogyne*,Vol. II; Barker K.R., Carter, C.C., Sasser J.N. (eds). pp.: 69-77.Graphics, North Carolina State University, USA.

Hua, X., Liu, N., Zhou, S., Zhang, L., Yin, H., Wang, G., Fan, Z., Ma, Y. 2020: Design, synthesis, and biological activity of novel aromatic amide derivativescontaining sulfide and sulfone substructures. Engr. 6: 553–559.

Huang, B., Wang, Q., Guo, M.X., Fang, W.S., Wang, X.N., Wang, Q.X., Yan, D.D., Ou Yang, C.B., Li, Y., Cao, A.C. 2019a: The synergistic advantage of combining chloropicrin or dazomet with fosthiazate nematicide to control root-knot nematode in cucumber production. Journal of Integrative Agriculture 18:20 93–106.

Hussey, R.S., Barker, K.R. 1973: A comparison of methods of collecting inocula for *Meloidogyne* spp., including a new technique. Pl. Dis. Reptr., 57: 1025- 1028.

Ibrahim, H.S., Saad, A.F.S.A., Massoud, M.A., Khalil, M.S. 2010: Evaluation of certain agrochemical and biological agents against Meloidogyne incognita on tomatoes. Alexandria Science Exchange Journal, 31(January-march): 10-17.

Ibrahim, I.K.A. 2011: Nematode pests parasitic on agricultural field crops. Manshaat El. Maaref, Alexandria: 2010.

IRAC 2015: Insecticide Resistance Action Committee, International Mode of Action Working Group,. IRAC Mode of Action Classification Scheme. Version 8.0

Ishibashi, N., Takii, S. 1993: Effects of Insecticides on movement, nictation, and infectivity of *Steinernema carpocapsae*. Jo. Nematolo, 25(2): 204– 213.

Jones, J.G., Kleczewski, N.M., Desaeger, J.S., Meyer, L., Johnson, G.C. 2017: Evaluation of nematicides for southern root-knot nematode management in lima bean. Crop protection, 96: 151- 157.

Jones, J.T., Haegeman, A., Danchin, E.G., Gaur, H.S., Helder, J., Jones, M.G., Kikuchi, T., Manzanilla-López, R., Palomares-Rius, J.E., Wesemael, W.M. 2013: Top 10 plant-parasitic nematodes in molecular plant pathology. Mol. Plant. Patholo. 14: 946–961.

Kepenekci, I., Hazir, S., Lewis, E. 2016: Evaluation of entomopathogenic nematodes and the supernatants of the *in vitro* culture medium of their mutualistic bacteria for the control of the root-knot nematodes *Meloidogyne incognita* and *M. arenaria*. Pest Manag. Sci. 72: 327–334.

Khalil, M.S., Alqadasi, A.A. 2019: Potential of non-fumigant nematicides at different formulations against southern root-knot nematode (*Meloidogyne incognita*) on tomato plants. International Jo. Phytopatholo. 8(1): 23-28.

Khalil, M.S, Abd El-Aziz, M.H., El-khouly, A.A.M. 2022: Optimization the Impact of Fluopyram and Abamectin against the Root-Knot Nematode (*Meloidogyne incognita*) on Tomato Plants by Using Trichoderma album. Egyptian Journal of Agronematology., 21(2): 79-90.

Knudsen, G.R., Bin, L.I. 1990: Effect of temperature, soil moisture, and wheat bran on growth of *Trichoderma harzianum* from alginate pellets phytopathology 80: 724- 727.

Li, B.X., Ren, Y.P., Zhang, D.X., Xu, S.Y., Mu, W., Liu, F. 2018: Modifying the formulation of abamectin to promote its efficacy on southern root-knot nematode (*Meloidogyne incognita*) under blending-of-soil and root irrigation

conditions. Journal of Agriculture and Food Chemistry 66:799–805.

Li, J.J., Meng, Z., Li, N., Dong, B., Ji, X.X., Zhang, S.A., Qiao, K. 2020: Evaluating a new non-fumigant nematicide fluopimomide for management of southern root-knot nematodes in tomato. Crop. Protection 129:105040.

Li, Q.Q., Li, J.J., Yu, Q.T., Shang, Z.Y., Xue, C.B. 2020: Mixtures of fluopyram and abamectin for management of in tomato. Journal of Nematology, 52(1): 1-11.

Masler, E. 2008: Responses of *Heterodera glycines* and *Meloidogyne incognita* to exogenously applied biogenic amines. *Nematology*, *10*(6), 911–917.

Massoud, M., Khalil, M., Shawer, R., El-bialy, M., Saad, A.F. 2021: Biological performance of certain Bio-Agents, Fluopyram and Fosthiazate against *Meloidogyne* spp. on guava trees (Psidium guajava L.). Alexandria science Exchange Journal, 42(4): 789 -797.

McCarter, J.P. 2008: Nematology: terra incognita no more. Nat. Biotechnol. 26: 882–884.

Morris, K.A., Langston, D.B., Davis, R.F., Noe, J.P., Dickson, D.W., Timper, P. 2016: Efficacy of various application methods of fluensulfone for managing root-knot nematodes in vegetables. Journal of Nematology, 48(2): 65-71.

Nelmes, A.J. 1970: Behavioral response of *Heterodera rostochiensis* larvae to aldicarb and its sulphoxide and sulphone. J. Nematol., 2:223-227.

Norton, D.C. 1978: Ecology of plant parasitic nematodes. Wiley, New York, 268 pp.

Opperman, C.H., Chang, S. 1990: Plant-parasitic nematode acetyl cholinesterase inhibition by carbamate and organophosphate nematicides. J. Nematol., 22: 481- 488.

Opperman, C.H., Chang, S. 1991: Effects of aldicarb and fenamiphos on acetylocholinesterase and motility of *Caenorhabditis elegans*. J. Nematol., 23:20–27.

Qiao, K., Liu, X., Wang, H., Xia, X., Ji, X., Wang, K. 2012: Effect of abamectin on root-knot nematodes and tomato yield. Pest management science, 68(6): 853-857.

Raddy, H.M., Fouad, A.F.A., Montasser, S.A., Abdel-Lateef, M.F., El-Samadisy, A.M. 2013: Efficacy of six nematicides and six commercial bioproducts against root-knot nematode, *Meloidogyne incognita* on tomato. Journal of Applied Sciences Research, 9(7): 4410-4417.

Radwan, M.A., Saad, A.S.A., Mesbah, H.A., Ibrahim, H.S., Khalil, M.S. 2019: Investigating the *in vitro* and *in vivo* nematicidal performance of structurally related macrolides against the root-knot nematode, *Meloidogyne incognita*. Hellenic Plant Prot. J. 12 (1): 24-37.

Saad, A.S.A., Massoud, M.A., Ibrahim, H.S., Khalil, M.S.H. 2012: Activity of Nemathorin, natural product and bioproducts against root-knot nematodes on tomatoes. Archives of Phytopatholo. Plant. Protec., 45, 955-962.

Saad, A.S.A., Radwan, M.A., Mesbah, H.A., Ibrahim, H.S., Khalil, M.S. 2017: Evaluation of some non-fumigant nematicides and the biocide avermactin for managing *Meloidogyne incognita* in tomatoes. Pakistan Jo. Nematolo., 35(1): 85-92.

Sharma, I.P., Sharma, A.K. 2015: Effects of initial inoculums levels of *Meloidogyne incognita* J_2 on development and growth of Tomato cv. PT-3 under control conditions. African Journal of Microbiology Res, 9: 1376-1380.

Sikora, R.A., Fernandez, E. 2005: Nematode parasites of vegetables. In: Luc, M., Sikora, R.A., Bridge, J. (Eds.), Plant-Parasitic Nematodes in Subtropical and Tropical Agriculture, second ed. CABI Publishing, Wallingford, UK, pp. 319–392.

Silva, J.D.O., Loffredo, A., da Rocha, M.R., Becker, J.O. 2019: Efficacy of new nematicides for managing *Meloidogyne incognita* in tomato crop. Journal of Phytopathology, 167(5): 295-298.

Stucky, T., Dahlin, P. 2022: Fluopyram: Optimal Application Time Point and Planting Hole Treatment to Control *Meloidogyne incognita.* Agronomy, 12(7): 15-76.

Sun, M.H., Gao, L., Shi, Y.X., Li, B.J., Liu, X.Z. 2006: Fungi and actinomycetes associated with *Meloidogyne* spp. eggs and females in China and their biocontrol potential. Journal of Invertebrate Pathology 93:22–28.

Sun, Y.P. 1950: Toxicity Index-an improved Method of comparing the relative 378 Toxicity of Insecticides. Journal of Economic Entomology, 43. 1.

Taylor, D.P., Nelscher, C. 1974: An improved technique for preparing perineal patterns of *Meloidogyne* spp. Nematology, 20: 268-269.

Tian, B.Y., Cao, Y., Zhang, K.Q. 2015: Metagenomic insights into communities, functions of endophytes and their associates with infection by rootknot nematode, *Meloidogyne incognita*, in tomato roots. Scientific Reports 5:1 70-87.

Whitehead, A.G., Hemming, J.R. 1965: A comparision of some quantitative methodsof extracting small vermiformnematodes from soil. Annals of Applied Biology, 55:25-38.

Wram, C.L., Zasada, I.A. 2019: Short-term effects of sublethal doses of nematicides on *Meloidogyne incognita*. Phytopathology, 109(9): 1605-1613.

Wright, D.J. 1981: Nematicides: Mode of action and new approaches to chemical control. In:

Plant parasitic nematodes (eds.B.M. Zuckerman and R.A. Rohde), Academic Press, New York, pp. 3:421-449.

Yue, X., Li, F., Wang, B. 2020: Activity of four nematicides against *Meloidogyne incognita* race 2 on tomato plants. Journal of phytopathology, 168(7-8): 399-404.

Zasada, I.A., Halbrendt, J.M., Kokalis-Burelle, N., LaMondia, J., McKenry, M.V., Noling, J.W. 2010: Managing nematodes without methyl bromide. Annu. Rev. Phytopathol. 48:311-328.

Table 1: Some physical and chemical properties of the tested soils (Obtained from Ashmoun district, Menofia Governorate).

Soil analysis														
	Chemical analysis										physical analysis			
Source of Soil Sample	pH	EC* dSm^{-1}	Soluble cations $meql^{-1}$				Soluble anions $meql^{-1}$				Particle size distribution			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	Total silt%	Total sandy%	Total clay%	Textural class
Ashmoun district, Menofiah governorate	8.7	3.35	9	4	18.48	2.11	0.0	6	14.8	12.79	14.02	45.30	40.85	Sandy Clay
	8.9	0.8	2.4	1.4	2.58	2.22	0.0	3.6	4.4	0.6	4.00	65.85	30.15	Sandy Clay loam

E.C* = Electric conductivity.

Table 2: List of the tested compounds.

Trade names (concentrations and formulations)	Common names	Chemical names (IUPAC)*	Rats of application fed^{-1}	Source of samples
Dento 40% EC	Fenamiphos	Ethyl 4-methylthio-*m*-tolyl isopropyl phosphoramidate	3.0 L	Star Chem Industrial Chemicals
Dina Tox 20% EW	Fosthiazate	(*RS*)-*S*-*sec*-butyl *O*-ethyl 2-oxo-1,3-thiazolidin-3-ylphosphonothioate.	2.5 L	Almadina Company
Tervigo 2% SC	Abamectin	A mixture containing $\geq$ 80 %Avermectins B1a (i) and $\leq$ 20% Avermectins B1b. (i1)	2.5 L	Syngenta Egypt
Velum Prime 40% SC	Fluopyram	*N*-{2-[3-chloro-5-(trifluoromethyl)-2-pyridyl] ethyl}-α, α, α-trifluoro-*o*-toluamide.	0.250 L	Bayer A.G-Egypt
Vydate 24% SL	Oxamyl	*N, N*-dimethyl-2-methylcarbamoyloxyimino-2-(methylthio) acetamide.	3.0 L	DuPont Egypt

EC=Emulsifiable Concentrate., EW= Emulsion in water. SC=Suspension Concentrate. SL=Soluble Concentrate.
IUPAC® names according to the International Union of Pure and Applied Chemistry (Anonymous, 2011).
Rate of application according to the Agricultural pesticide committee (APC), Ministry of Agricultural Land Reclamations (MALR).

Table 3: Toxicity of five nematicides on second-stage juvenile (J_2) of root-knot nematode (*Meloidogyne incognita*) after 24, 48 and 72 hrs from exposure under laboratory conditions.

Trade names (concentrations and formulations)	Common names	Time (Hours)	LC_{50} values.* mg l^{-1} (lower – upper limits)	LC_{90} values.* mg l^{-1} (lower – upper limits)	LC_{20}values mg l^{-1} (lower – upper limits)	LC_{15}values mg l^{-1} (lower – upper limits)	LC_{10}values mg l^{-1} (lower – upper limits)	Slope values ±SE***
Dento 40% EC	Fenamiphos	24	14.91 (9.84-21.63)	92.08 (72.22-222.21)	4.51 (2.14-5.82)	3.42 (1.47-4.37)	2.41 (0.92-3.07)	1.62±0.131
		48	12.73 (8.37-17.90)	57.52 (45.84-114.29)	4.73 (2.43-5.96)	3.76 (1.80-4.67)	2.82 (1.24-3.45)	1.95±0.135
		72	10.41 (5.59-15.95)	46.11 (40.33-140.15)	3.92 (1.30-4.50)	3.12 (0.91-3.40)	2.35 (0.58-2.40)	1.98±0.151
Dina Tox 20% EW	Fosthiazate	24	10.94 (6.38-23.09)	48.15 (62.15-298.63)	4.13 (1.26-4.89)	3.30 (0.85-3.46)	2.48 (0.51-2.26)	1.99±0.14
		48	8.61 (4.86-15.85)	40.64 (40.93-161.07)	3.08 (1.06-3.75)	2.43 (0.73-2.72)	1.80 (0.46-1.82)	1.89±0.1268
		72	7.46 (4.32-14.86)	45.70 (47.20-234.92)	2.27 (0.75-2.88)	1.72 (0.49-2.01)	1.21 (0.28-1.29)	1.62±0.121
Tervigo 2% SC	Abamectin	24	7.19 (3.79-13.00)	55.45 (48.87-229.92)	1.88 (0.58-2.38)	1.38 (0.37-1.63)	0.93 (0.20-1.03)	1.44±0.10
		48	5.39 (2.53-9.45)	35.68 (29.83-133.09)	1.56 (0.43-1.91)	1.17 (0.28-1.33)	0.81 (0.16-1.86)	1.56±0.10
		72	4.89 (1.91-10.61)	40.79 (43.82-357.40)	1.21 (0.19-1.35)	0.88 (0.10-0.85)	0.58 (0.05-0.48)	1.39±0.106
Velum prime 40% SC	Fluopyram	24	4.20 (2.17-7.32)	19.72 (15.83-63.28)	1.52 (0.52-1.99)	1.20 (0.37-1.49)	0.89 (0.24-1.04)	1.90±0.13
		48	3.47 (1.79-5.91)	16.25 (12.29-46.05)	1.26 (0.45-1.69)	1.00 (0.33-1.28)	0.74 (0.21-0.90)	1.91±0.12
		72	2.44 (1.25-4.18)	14.23 (10.07-38.26)	0.76 (0.28-1.08)	0.58 (0.20-0.80)	0.41 (0.12-0.55)	1.67±0.10
Vydate 24% SL	Oxamyl	24	10.48 (6.39-17.09)	25.46 (26.61-78.94)	5.85 (2.36-6.30)	5.11 (1.86-5.35)	4.31 (1.38-4.11)	3.32±0.241
		48	9.53 (6.71-14.46)	25.66 (24.79-64.96)	4.97 (2.59-5.92)	4.28 (2.05-4.87)	3.54 (1.53-3.82)	2.98±0.22
		72	8.97 (5.95-14.24)	25.02 (25.34-73.95)	4.57 (2.08-5.34)	3.91 (1.61-4.30)	3.21 (1.16-3.29)	2.87±0.21

*LC_{50} values (i.e., lethal concentration required to kill 50% of the population).
**LC_{90} values (i.e., lethal concentration required to kill 90% of the population).
***SE = Standard Error.

Table 4: Toxicity index and relative potency of treatments on second stage(J_2) of root-knot nematode *(Meloidogyne incognita)* based on the LC_{50} values at 24, 48 and 72 hrs from exposure under laboratory conditions.

Trade names (concentrations and formulations)	Common names.	Toxicity index (T.I).*			Relative potency (R.P). **		
		24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs
Dento 40% EC	Fenamiphos	28.16	27.26	23.44	03.55	03.67	04.27
Dina Tox 20% EW	Fosthiazate	38.39	40.30	32.71	02.60	02.48	03.06
Tervigo 2% SC	Abamectin	58.41	64.38	49.90	01.72	01.28	02.01
Velum prime 40% SC	Fluopyram	100.00	100.00	100.00	01.00	01.00	01.00
Vydate 24% SL	Oxamyl	40.08	36.41	27.21	02.49	02.75	03.68

*T.I. = Toxicity index was calculated by LC_{50} of the most effective compound/ LC_{50} of the tested compound × 100. by (Sun, 1950).
**R.P. = Relative potency was calculated by LC_{50} of the least tested compound / LC_{50} of the most effective compound. by (El- Sheikh and Aamir, 2011).

Table 5: Effect of treatments on egg hatching of root-knot nematode (*Meloidogyne incognita*) after 72 hrs from exposure under laboratory conditions.

Trade names (concentrations and formulations).	Common names	EC_{50} values* (lower-upper)	EC_{90} values** (lower-upper)	Slop values ±SE.***	Toxicity index (T.I). **** at LC_{50} value	Relative potency (R.P). ***** at LC_{50} value
Dento 40% EC	Fenamiphos	06.73 (4.00-9.89)	76.65 (51.98-178.10)	01.21±0.09	29.12	03.44
Dina Tox 20% EW	Fosthiazate	09.59 (6.18-13.87)	81.76 (57.42-177.69)	01.37±0.10	20.44	04.89
Tervigo 2% SC	Abamectin	01.96 (0.99-3.11)	32.58 (20.95-77.93)	01.05±0.08	100.00	01.00
Velum prime 40% SC	Fluopyram	02.23 (1.68-2.84)	35.11 (25.59-52.13)	01.07±0.08	87.89	01.14
Vydate 24% SL	Oxamyl	07.84 (4.86-11.45)	84.69 (57.62-193.84)	01.24±0.09	25.34	04.00

*EC_{50} values (effective concentration that inhibit 50% of nematode egg hatching)
**EC_{90} values (effective concentration that inhibit 90% of nematode egg hatching)
***SE. = Standard Error.
****T.I = Toxicity index was calculated by LC_{50} of the most effective compound/ LC_{50} of the tested compound × 100. by (Sun, 1950).
****R.P = Relative potency was calculated by LC_{50} of the least tested compound / LC_{50} of the most effective compound.by (El- Sheikh and Aamir., 2011).

Table 6: Estimation the reversible effect of nematicides (nematode recovery after treatment of nematicides) of treatments on immobile second stage of root-knot nematode (*Meloidogyne incognita*) at 1 and 24 hrs after time of exposure under laboratory conditions.

Trade names (concentrations and formulations).	Common names	%Immobile*		Recovery%** at LC_{15} value.		Recovery% at LC_{50} value.	
		at LC_{15}	at LC_{50}	One hrs	24 hrs	One hrs	24 hrs
Dento 40% EC	Fenamiphos	29.68	48.93	85.27	93.02	84.30	87.96
Dina Tox 20% EW	Fosthiazate	28.47	54.10	88.21	94.07	81.00	87.98
Tervigo 2% SC	Abamectin	78.81	91.18	03.01	04.49	00.53	01.25
Velum prime 40% SC	Fluopyram	78.00	94.44	81.42	87.25	74.77	76.95
Vydate 24% SL	Oxamyl	38.10	58.94	82.65	92.19	80.90	80.42

*%Immobile = No. of immotile nematode / Total number nematode × 100.
**Recovery%= No. of motile nematode / No. of immotile nematode × 100.

Table 7: Effect of five nematicides on egg differentiation of *M. incognita* after immersion for 18 days under laboratory conditions.

Trade names (concentrations and formulations)	Common names	Concentrations mg l^{-1}	Mean No. of egg differentiation ±S.E.*	Reduction% of differentiation.**
Dento 40% EC	Fenamiphos	01.00	97.00 ±04.93 ^{d}	47.57
		10.00	46.00 ±04.51 ^{hi}	75.14
		50.00	23.00 ±03.21 ^{jk}	87.57
Dina Tox 20% EW	Fosthiazate	01.00	170.00 ±04.16^{b}	08.11
		10.00	86.00 ±03.46^{de}	53.51
		50.00	57.00 ±01.53 ^{gh}	69.19
Tervigo 2% SC	Abamectin	01.00	35.00 ±02.08 ^{ij}	81.08
		10.00	31.00 ±02.08 ^{j}	83.24
		50.00	15.00 ±00.58 ^{kl}	91.89
Velum prime 40% SC	Fluopyram	01.00	79.00 ±05.51 ^{ef}	57.30
		10.00	26.00 ±02.00 ^{jk}	85.95
		50.00	08.00 ±03.06 ^{l}	95.68
Vydate 24% SL	Oxamyl	01.00	161.00 ±02.00 ^{b}	12.97
		10.00	141.00 ±05.03 ^{c}	23.78
		50.00	67.00 ±02.89 ^{fg}	63.78
Untreated check	_____	00.00	185.00 ±07.23 ^{a}	00.00
LSD. For:-			LSD at 5%	
T = treatment			= 07.13	
C = concentration			=05.00	
T×C =			=12.35	

Reduction in egg differentiation (%) = C-T/C ×100.

Where: - C = No. of differentiation in control and T = No. of differentiation treatment.

Table 8: Effect of treatments on the development and reproduction of root–knot nematode (*M. incognita*) infecting tomato plants (cv. carioca) growing under greenhouse conditions.

Trade names (concentrations and formulations).	Common names	No. of galls $plant^{-1}$ ±SE.*	No. of larvae in soil (J_2) ±SE	No. of developmental stages $root^{-1}$±SE.	No. of egg masses $root^{-1}$±SE.	No. of eggsegg-$mass^{-1}$ ±SE.	Final population (Pf).	Reproduction Factor (Rf)**.	Nematicides Efficiency%***
Dento 40% EC	Fenamiphos	97.66 ±03.18^{c}	27.66 ±00.88 ^{cd}	58.33 ±03.53 ^{d}	38.00 ±01.73 ^{de}	57.33 ±00.67 ^{c}	2302.67	01.92	92.70
Dina Tox 20% EW	Fosthiazate	47.66 ±02.03^{e}	29.66 ±00.88 ^{c}	69.33±01.20 ^{c}	135.33±00.88 ^{b}	59.33 ±01.76 ^{c}	3276.56	02.73	89.62
Tervigo 2% SC	Abamectin	167.33 ±04.48^{b}	84.66±00.88 ^{b}	127.33 ±03.48 ^{b}	135.00 ±02.19 ^{b}	183.66 ±02.85 ^{b}	25203.56	21.00	20.15
Velum prime 40% SC	Fluopyram	41.00 ±01.53 ^{e}	23.66 ±02.03 ^{d}	45.00±02.03 ^{e}	35.33±01.20 ^{e}	27.33 ±00.88 ^{e}	1070.11	00.89	96.62
Vydate 24% SL	Oxamyl	64.66±01.86 ^{d}	28.66 ±00.88 ^{c}	52.00 ±02.52 ^{de}	42.66 ±01.86 ^{d}	42.66 ±2.19 ^{d}	1943.78	01.62	93.84
Untreated check	----------	186.00 ±02.65 ^{a}	98.00 ±02.08 ^{a}	141.33±03.71 ^{a}	155.33 ±02.60 ^{a}	200.66 ±02.60 ^{a}	31564.89	26.30	0.00
	L.S.D at 5%	08.63	04.27	08.91	05.65	06.16	----------	----------	

Differences between means in each column followed by the same small letter (s) are not significant atP>0.05 according to Duncan's multiple range test.

*SE. = Standard Error.

Rf = *Pf* / *Pi* where: - *Pf* = nematode final population and *Pi* = nematode initial inoculum (1200J_2).

Nematicides Efficiency%= Rf. Control – Rf. Treatment / Rf. Control ×100.

Table 9: Effect of nematicides on the growth of tomato plants (cv. Carioca) growing under greenhouse conditions.

Trade names (concentrations and formulations)	Common names	Sandy clay soil			
		Length (cm).* ±SE***		Fresh weight (gm). ** ±SE	
		Shoot	Root	Shoot	Root
Dento 40% EC	Fenamiphos	47.18±00.41 a	20.60±00.97 b	13.27±00.18 ab	06.52±00.24 bc
Dina Tox 20% EW	Fosthiazate	47.28±00.17 a	23.16±00.42 a	13.86±00.10 ab	07.03±00.21 ab
Tervigo 2% SC	Abamectin	43.33±00.50 b	16.10±00.45 c	11.31±00.35 c	05.94±00.16 c
Velum prime 40% SC	Fluopyram	47.63±00.88 a	23.25±00.50 a	13.99±00.07 a	07.27±00.25 a
Vydate 24% SL	Oxamyl	47.21±00.40 a	21.56±00.97 ab	13.79±00.21 ab	06.79±00.15 ab
Untreated check	Untreated check	41.60±00.80 c	14.96±00.15 c	10.91±00.49 c	04.79±00.25 d
Non-inoculated	Non-inoculated	46.30±00.51 a	20.10±00.80 b	13.02±00.44 b	06.63±00.37 abc
L.S.D at 5%	----------	01.73	02.04	00.92	00.73

Differences between means in each column followed by the same small letter (s) are not significant at *P <0.05* according to Duncan's multiple range test.
*Leanth calculated by (cm).
**Fresh weight calculated by (gm).
***SE = Standard Error.

كفاءة بعض المبيدات النيماتودية ضد نيماتودا تعقد الجذور على الطماطم تحت ظروف المعمل والصوبة

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الملخص العربى

تمت دراسة تأثير خمسه من مبيدات النيماتودا وهي (ترفيجوSC 2 % (أبامكتين) و دينتو EC 40% (فيناميفوس) و دينا توكس EW 20% (فوسيازيت) و فايديت SL 24% (أوكساميل) و فيلوم برايم SC 40% (فليوم بيرام) في مكافحة نيماتودا تعقد الجذور *Meloidogyne incognita* في محصول الطماطم تحت ظروف المعمل والصوبه. أوضحت نتائج المعمل أن قيم الـ LC_{50} هي 5.39 و 12.73 و 8.61 و 9.53 و 3.47 جزء فى المليون على التوالي. وكانت مبيدات الفليوم بيرام والأبامكتين هي الأكثر كفاءة. كما أوضحت التجارب أن جميع المعاملات قد أثرت على نسبة فقس البيض وكانت مبيدات الأبامكتين والفليوم بيرام هي أفضل المبيدات فى خفض نسبة فقس وتمايز بيض نيماتودا تعقد الجذور. بينت النتائج أيضاً أن مبيد الأبامكتين هو مبيد النيماتودا الوحيد الذي تسبب في شلل لا رجعة فيه. وأوضحت نتائج الصوبه والتي أجريت في الأصص بالصوبه أن جميع المعاملات كان لها تأثيرمعنوي في خفض تطور ومعدل التكاثر (RF) للنيماتودا. بالإضافة إلى ذلك ، حقق فلوبيرام أكبر انخفاض في أعداد العقد ومعدل التكاثر (RF) لنيماتودا تعقد الجذور على نباتات الطماطم في الصوبه.

الكلمات الاسترشادية: مبيدات النيماتودا، التمايز، الطماطم.