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# Nematicidal Activity of Jojoba Oil, Potassium Silicate and Bio-Nematon Singly or Integrated against *Meloidogyne incognita, in Vitro*, and *in Vivo*

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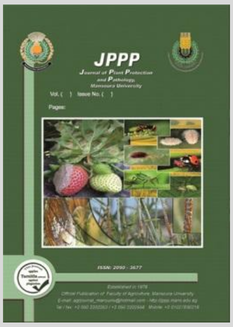

## ABSTRACT

Two experiments were conducted to determine the nematicidal activity of jojoba oil, potassium silicate and Bio-Nematon (a commercial product of *Paecilomyces lilacinus*) singly or integrated against root-knot nematode, *Meloidogyne incognita in vitro*, and *in vivo*. All treatments recorded a significant increase ($P \leq 0.05$) in the mortality rate of *M. incognita* juveniles depending on the type of treatments and duration of exposure. The triple treatment recorded the best results, followed by the double treatment, and finally the individual treatments. The triple treatment of jojoba oil with potassium silicate and the nematicide oxamyl achieved the best results among all tested treatments with values of 113.60, 147.18, and 105.20% for plant height, plant weight, and dry weight of the vegetative mass, respectively as well as achieved the best results among all treatments in reducing the tested nematode metrics with values of 81.85, 82.59 and 82.86%, for nematode juveniles, galls, and egg masses counts, respectively. Similarly, there was a significant increase in the concentrations of nitrogen, phosphorus, potassium, and total phenolic compounds by tri-treatment, with values of 2.47, 0.556, 2.90, and 30.57%, respectively, alongside a low total chlorophyll content in the leaves of tomato plant was recovered.

***Keywords:*** nematicidal activity, jojoba oil, potassium silicate, Bio-Nematon, integrated, *M. incognita, in vitro, in vivo.*

## INTRODUCTION

Root-knot nematodes, *Meloidogyne* spp., have been identified as a main factor preventive agricultural production in several regions of the biosphere. The use of nematicides for nematode management is encouraged because it causes pollution and poses health risks to humans and animals. Many researchers have focused on non-chemical substances as biological control agents against plant-parasitic nematodes. The use of medicinal plants and essential plant oils such as jojoba oil (*Simmondsia chinensis* L.) has been found to reduce the populations of some plant nematodes when grown with sensitive crops, using their extracts or products (El-Nagdi, 2005; El-Nagdi et al., 2009; Ismail et al., 2009 and 2011; Ahmed et al., 2012 and El-Saedy et al., 2014). Jojoba oil is considered one of the most important of these substances, as it is wholly different in structure from all other vegetable oils. It is chemically classified as a waxy liquid resulting from the union of fatty acids and alcohol with a long carbon chain containing 40-44 carbon atoms, which is why it is used in multiple fields (Yermanos, 1975). Furthermore, jojoba oil is one of the substitutes to nematicides as it has the potential to eliminate mites and sucking insects, fungal diseases of plants, and control nematodes (Mostafa et al., 2017). Some soil amendments containing inorganic fertilizers release ammonium nitrogen in the soil, directly reducing nematode populations, and promoting the selective growth of nematode-antagonistic microbes. In general, nutrients can make plants more susceptible to disease attacks, either directly or indirectly. They can decrease or increase disease severity, affect the environment to attract or repel pathogenic factors, and stimulate resistance or tolerance in the host plant. Potassium silicate is a source of highly soluble potassium and silicon, primarily used in agricultural production systems as silica additions, providing small amounts of potassium. Potassium silicate reduced levels of *Tylenchulus semipenetrans* in the soil ( El-Sherif et al., 2015).Bottom of Form

Bio-Nematon (a commercial formulation of the fungus *Paecilomyces lilacinus* is a biological nematicide that attacks and kills eggs and mature females, reducing the population density of parasitic nematodes. Additionally, *Purpureocillium lilacinum* (formerly *Paecilomyces lilacinus*) may release leucin toxins, which are highly effective against plant-parasitic nematodes (Ibrahim et al., 2019). The nematicidal activity of Bio-Nematon containing the fungus *Paecilomyces lilacinus* as a biological agent may be due to increased frequency in the treated root area of saprophytic fungi (El- Nagdi, 2011). *P. lilacinum* has a high parasitic capability for eggs (80%) as well as for egg masses and cysts (Goswami and Mittal, 2002; and Sharf et al., 2011). It can also infect different stages of the genus *Meloidogyne* spp. (Yang et al., 2015). Therefore, two trials were conducted to study the nematicidal activity of jojoba oil, potassium silicate and Bio-Nematon singly or integrated against *M. incognita, in vitro,* and *in vivo.*

## MATERIALS AND METHODS

### Chemical nematicide

Oxamyl: (Vydate 10% G.) Methyle – N– N– dimethyl – (N (methyl) carbomycocyl) - 1- Thioxamidate.

### Bionematicide

Bio-Nematon 1% WP (the commercial product of *Paecilomyces lilacinus*) containing $1 \times 10^4$ colony-forming units/mg of the fungus was undertaken. A solution of 2.5g/100ml distilled water was prepared. Bio-Nematon was added at a rate of 10 ml / plant/ pot. It was obtained from the Nematode Research Department, Plant Pathology Institute, Agricultural Research Center, Giza, Egypt.

### Jojoba oil

Jojoba oil was obtained from Department of Chemistry Faculty of Agriculture, Mansoura University.

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Jojoba oil was applied one week after transplanting as drenching at the concentration of 400 ml / litter water.

**Potassium silicate** ($K2SiO3$) was obtained from Department of Soil, Faculty of Agriculture, Mansoura University, Potassium silicate was applied one week after transplanting as drenching at the concentration of 6ml / litter water.

**Root-knot nematode stock culture, preparing nematode inoculum:**

Infected coleus, *Coleus blumei* root systems with heavily egg masses of *M. incognita* that was previously recognized according to Taylor and Sasser (1978), were maintained at the greenhouse of Nematological Research Unit (NERU) of Agricultural Zoology Department, Faculty of Agriculture, Mansoura University, Egypt and served as a source of nematode inocula. The second stage of *M. incognita* inoculum (J2) was prepared by extracting it from the soil of infected coleus roots by sieving and modified Baermann technique (Goodey, 195.

**The nematicidal activity of jojoba oil, potassium silicate and Bio-Nematon singly or integrated on the *M. incognita* juveniles mortality:**

A laboratory trial was conducted to evaluate the nematicidal activity of jojoba oil, potassium silicate and Bio-Nematon singly or integrated on the second stage juveniles mortality of *M. incognita*. The experiment was conducted using the randomized complete block design with four replications for 12 treatments including: Jojoba oil (J): Potassium silicate (PS): Bio-Nematon (BN): Oxamyl (OX): J +PS: J+ BN: J+ OX: PS+BN: PS+ OX: J+ PS+ OX and nematode alone as control. Ten ml of each treatment were placed in 9 cm in diameter Petri-dishes. About 100 newly hatched second stage juveniles in 0.2 ml of distilled water were added to each Petri-dish. The control treatment was ten ml sterilized distilled water with the same number of juveniles. Four replicates were used for each treatment. The dead juveniles as those showing no movement (non- active) and of normal movement were counted using (100X) magnification after 24, 48 and 72 h under light microscope. The following formula was used to calculate formula and percent mortality: Mortality rate (%) = [(number of dead juveniles/ Total juveniles' number) × 100.

**The nematicidal activity of jojoba oil, potassium silicate and Bio-Nematon singly or integrated on *M. incognita in vivo*.**

Integrated studies were conducted between jojoba oil, potassium silicate and bio-Nematon as individual or dual treatments or with oxamyl as a triple treatment compared to oxamyl (10%G) against *M. incognita* affecting tomatoes under greenhouse conditions. Thirty-nine plastic pots (11 cm diameter) containing 900 grams of steam-sterilized sandy clay soil (1:1) with 33-day-old tomato seedlings were used. One week after planting the tomato seedlings, 1200 $J_2$s of *M. incognita* were inoculated on thirty-six seedlings, leaving three seedlings without nematodes to serve as a control group. After a week, the tested materials were added to three seedlings each and mixed with the soil, while three seedlings (pots) were left with nematodes only without any treatment. Each treatment was repeated three times. The treatments were as follows:

**1**. N +Jojoba oil (10 ml /pot),
**2**. N + Potassium silicate (10 ml /pot),
**3**. N +Bio-Nematon (10 ml / pot),
**4**. N + {½ Jojoba oil (5ml) + ½ Potassium silicate (5ml)},
**5**. N + {½ Jojoba oil (5ml) + ½ Bio-Nematon (5ml)},
**6**. N + {½ Bio-Nematon (5ml) + Potassium silicate (5ml)},
**7**. N + {½ Jojoba oil (5ml) + ½ Oxamyl (0.15g)},
**8**. N + {½ Potassium silicate (5 ml) + ½ Oxamyl (0.15g)},
**9**. N + {⅓ Jojoba oil + ⅓ Potassium silicate + ⅓ Oxamyl},
**10**.N + {⅓ Jojoba oil + ⅓ Potassium silicate + ⅓ Bio-Nematon},
**11**. N + Oxamyl (0.3g /plant),
**12**. Nematode alone and
**13**- Plant free of nematode.

The plastic pots were then arranged in a completely randomized block design and irrigated with tap water as needed. The plants were harvested 45 days after nematode inoculation, and growth parameters were determined and recorded, including shoot and root lengths and fresh weights, as well as dry shoot weights. The number of M. incognita (J2s) in 250 grams of soil/pot were extracted by sieving and modified Baermann technique (Goodey, 1957) and calculated using a Hawkesley slide under ×10 magnification, then calculated for all pot and detailed. The infested roots of each plant were washed away by tap water, fixed in 4% formalin for 24 hours, and stained in 0.01% lactic acid-fuchsin (Byrd et al., 1983), and then inspected for the number of galls and egg masses. The root gall index (RGI) and egg mass index (EI) were predestined on 0-5 scale according to Taylor and Sasser (1978).

**Chemical analysis:**

Sections of dry leaves were digested and nitrogen (N), phosphorus (P), potassium (K) were determined according to kjeldahl methods (A.O.A.C,1980).

**Chlorophyl content:**

Represented samples of tomato fresh leaves were evaluated for chlorophyll a, b and together a+b was calculated following equation that were used for the design pigments content according to Goodwin (1965).

**Determination of total phenols:**

In this experiment, total phenols in fresh leaves were measured according to Folin-Ciocalteau reagent (Kaur and Kapoor. 2001).

**Determination of elemental carbon concentrations**

Freeze-tomato dried leaf material (10 mg) was used for the determination of the elemental carbon concentration according to Moreno-Pedraza et al. (2019).

**Statistical Analysis:**

The extracted data were subjected to analysis of variance (ANOVA) using Costate software. The mean differences were compared using the LSD. 5%.

## RESULTS AND DISCUSSION

Data documented in Table (1) revealed the nematicidal activity of jojoba oil (J), potassium silicate (PS) and Bio-Nematon (BN) singly or integrated on *M. incognita* juveniles mortality *in vitro* after three times intervals. It was evident that all treatments recorded a significant ($P \leq 0.05$) increase in the rate of *M. incognita* juveniles' mortality depending on the type of treatments and the duration of exposure. In general, the triple treatment recorded the best results, followed by the double, and finally the individual treatments. The triple treatment of jojoba oil with potassium silicate, in addition to the oxamyl (OX) as a nematicide, recorded the highest values 90% of *M. incognita* juveniles mortality, as compared to control. Meanwhile, the double treatment of potassium silicate with oxamyl showed the best mortality values among the double treatments at a rate of 73%. The individual treatment with Bio-Nematon recorded the highest values among the individual treatments at a rate of 56%. On the other hand, oxamyl recorded the highest rate among all treatments in increase juveniles mortality at a value of 92% as compared to control.

**Table 1. Nematicidal activity of jojoba oil, potassium silicate and Bio-Nematon singly or integrated on juveniles mortality of *Meloidogyne incognita, in vitro* after three times intervals.**

| Treatments | Mean number of juveniles mortality after three intervals (hrs.) | | | Juveniles mortality (%) |
|---|---|---|---|---|
| | 24hr | 48hr | 72 hr | |
| J | 35j | 39h | 48j | 48.0 |
| PS | 40i | 51f | 54i | 54.0 |
| BN | 44h | 48g | 56h | 56.0 |
| OX | 79a | 88a | 92a | 92.0 |
| J+PS | 48g | 50f | 60g | 60.0 |
| J+BN | 55e | 58e | 64f | 64.0 |
| J+OX | 55e | 59e | 68e | 68.0 |
| PS+BN | 51f | 58e | 68e | 68.0 |
| PS+OX | 69d | 71d | 73d | 73.0 |
| J+PS+BN | 75c | 83c | 88c | 88.0 |
| J+PS+OX | 77b | 86b | 90b | 90.0 |
| Control | 2k | 4i | 6k | 6.0 |
| LSD | 0.54 | 0.91 | 0.95 | ---- |

**J=Jojoba oil; PS= Potassium silicate; BN= Bio- Nematon; OX=Oxamyl**
**N= 100 *M. incognita* second stage juveniles**
**Means followed by the same letters in each column are not significantly different at 5% level according to Duncan's multiple range test.**

These results are consistent with other researchers who studied the nematicidal properties of jojoba oil (Gomaa et al., 2016; El Nagdi et al., 2017; Hafez et al., 2017). The inhibitory effect of the tested materials may be credited to the existence of chemicals with nematicidal effects. This nematicidal activity is owing to the existence of compounds such as isothiocyanates, thiophenes, glucosides, and alkaloids.

Data within Table (2) illustrate the efficacy of jojoba oil, potassium silicate, and Bio-Nematon, whether used individually or in combination, on tomato plants under the influence of root-knot nematode infestation in greenhouse conditions. The results showed that totally treatments achieved clear improvements in the tested plant metrics to varying degrees. Generally, the triple treatments recorded better results than the double treatments, followed by the individual treatments. On the other hand, the individual treatments showed varying results, with the treatment using the oxamyl yielding the best outcomes in improving plant metrics, with values of 124.39, 169.27, and 112.00% for plant height, plant weight, and dry weight of the vegetative mass, respectively. While the second rank in individual treatments was achieved by Bio-Nematon application, which recorded average values in the improvement of the tested plant metrics at rates of 57.30, 54.09, and 40.80% for plant height, weight, and dry weight of the vegetative mass, respectively. On the other hand, the treatment with jojoba oil recorded the lowest values in this context. When the nematicide, oxamyl was added with jojoba oil as a double application at half rate, high values were recorded in the improvement of plant at 81.66, 90.73, and 80.0%, respectively, for the same previous metrics. The dual treatment of potassium silicate with oxamyl recorded the highest values among the dual treatments at rates of 93.18, 124.55, and 84.00%, respectively, for plant height, weight, and dry weight of the vegetative mass. The triple treatment of jojoba oil with potassium silicate and the nematicide achieved the best results among all tested treatments with values of 113.60, 147.18 and 105.20%, respectively, for the tested plant metrics.

**Table 2. Effectiveness of jojoba oil, potassium silicate and Bio-Nematon singly or integrated on tomato growth response under the stress of *Meloidogyne incognita* infection *in vivo*.**

| Treatments | *Plant growth response | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Length (cm) | | Total plant length (cm) | ** Inc.% | Total plant fresh weight (g) | | Total plant f.wt (g) | ** Inc.% | Shoot dry weight (g) | ** Inc.% |
| | Shoot | Root | | | Shoot | Root | | | | |
| J | 50.00 f-h | 19.26 f-h | 69.26 | 40.63 | 11.50 j-l | 3.43 f-h | 14.93 | 35.73 | 2.83 h-j | 13.20 |
| PS | 53.62 e-g | 21.25 d-f | 74.87 | 52.02 | 12.00i-k | 3.15 g-i | 15.15 | 37.73 | 3.15 g-i | 26.00 |
| BN | 54.87 e-g | 22.60cd | 77.47 | 57.30 | 13.50 h-j | 3.45 f-h | 16.95 | 54.09 | 3.52f-h | 40.80 |
| Ox | 80.25 b | 30.26a | 110.51 | 124.39 | 23.90 b | 5.72 bc | 29.62 | 169.27 | 5.30 ab | 112.00 |
| J+PS | 65.50 d-f | 22.25 cd | 87.75 | 78.17 | 14.00 g-i | 4.24 e-g | 18.24 | 65.82 | 3.91 e-g | 56.40 |
| J+BN | 65.00 d-f | 21.90de | 86.9 | 76.45 | 15.00f-h | 4.93 d-f | 19.93 | 81.18 | 4.08 d-f | 63.20 |
| J+OX | 66.46 d-f | 23.006 c | 89.466 | 81.66 | 16.00 e-g | 4.98 de | 20.98 | 90.73 | 4.50 c-e | 80.00 |
| PS+BN | 71.00 c-e | 20.83 e-g | 91.83 | 86.46 | 17.95 d-f | 5.03 cd | 22.98 | 108.91 | 4.51 c-e | 80.40 |
| PS+OX | 70.93 c-e | 22.25 cd | 93.18 | 89.20 | 19.00 c-e | 5.70 bc | 24.70 | 124.55 | 4.60 cd | 84.00 |
| J+PS+BN | 74.56 b-d | 23.00 c | 97.56 | 98.09 | 20.85 cd | 5.93 b | 26.78 | 143.45 | 4.70 c | 88.00 |
| J+PS+OX | 78.70 bc | 26.50 b | 105.2 | 113.60 | 21.22 c | 5.97 b | 27.19 | 147.18 | 5.13 b | 105.20 |
| N alone | 33.00 i | 16.25 i | 49.25 | 0.00 | 9.00 m | 2.02 j | 11.02 | 0.00 | 2.50 jk | 0.00 |
| Control | 84.90a | 30.00a | 114.9 | 133.30 | 26.00a | 7.00 a | 33.00 | 200.00 | 5.70 a | 128.00 |
| L.S.D | 3.463 | 1.054 | -- | --- | 2.025 | 0.451 | | -- | 0.342 | --- |

**J=Jojoba oil; PS= Potassium silicate; BN= Bio- Nematon; OX=Oxamyl**
**N = 1200 ($J_{2s}$) of *M. incognita*** *** Each figure is the mean of three replicates**
**Means in each column followed by the same letter(s) did not differ at p<0.05 according to Duncan's multiple range test.**
****Increase % = (Treatment - N alone) / N alone *100.**

Data within Table (3) illustrate the effect of jojoba oil, potassium silicates and Bio-Nematon whether applied individually or in combination as dual or triple treatments, on the nematode metrics affecting tomato plants under greenhouse conditions. Generally, treatments recorded significant ($p<0.05$) results in reducing nematode counts with varying values. The triple and dual treatments showed the best results in this regard, followed by the individual treatments. The nematicide, oxamyl ranked first in reducing juvenile counts in 250g soil, nematode galls, and egg masses with values of 85.1, 92.4 and 94.3%, respectively as compared to nematode alone. The application with Bio-Nematon recorded the best values among the individual treatments with values of 25.9, 64.3 and 68.6%, respectively, while jojoba oil ranked last with values of 18.8, 46.4 and 57.1%, respectively for the same previous nematode metrics. However, the least reproduction factor (RF=0.19) was recorded with triple application including jojoba oil, potassium silicate and oxamyl.

Bio-Nematon has been shown to be highly effective in controlling nematode populations. It is particularly effective against root-knot nematodes (Meloidogyne spp.), which are common pests in agricultural crops (Sivakumar et al., 2020). Studies have demonstrated that Bio-Nematon can achieve up to 68.2% reduction in M.incognita final nematode population on fig plants, outperforming other biocides like Anti-Nema and NemaStop (Hendy et al., 2023). This significant reduction in nematode population can lead to improved plant growth and increased yields. Bio-Nematon works by attacking eggs and females of sedentary nematodes, thereby reducing their population. It has been shown to be effective in reducing M.incognita population and improving tomato and cowpea parameters as well as boosting chemical constituents (Metwally et al., 2019 Khairy, 2021, Khairy et al., 2021).

However, the dual treatment of potassium silicate combined with the pesticide oxamyl at half rate showed the best values among the dual treatments with values of 78.9, 80.4 and 74.3% for soil nematode juveniles, galls, and egg masses counts, respectively. The triple treatment of jojoba oil and potassium silicates with oxamyl achieved the best results among all treatments in reducing the tested nematode metrics with values of 81.8, 82.6 and 82.9%, respectively. It is stimulating to note that the RGI and EI of the tested treatments showed variable values compared to nematodes. At the same time, oxamyl as a nematicide provided the least value for the RGI and EI, recording 2 and 1 compared to 5 for nematodes only, respectively.

**Table 3. Effectiveness of jojoba oil, potassium silicate and Bio-Nematon singly or integrated on *Meloidogyne incognita* affecting tomato plants under greenhouse conditions.**

| Treatments | No. juveniles in 250g soil | Red. % | RF | No. galls | Red. % | RGI | No . egg-masses | Red.. % | EI |
|---|---|---|---|---|---|---|---|---|---|
| J | 1700.0 b | 18.8 | 0.85 | 30.0 b | 46.4 | 3 | 15.0 b | 57.1 | 3 |
| PS | 1678.0 c | 19.9 | 0.84 | 23.0 c | 58.9 | 3 | 13.0 bc | 62.9 | 3 |
| BN | 1551.2d | 25.9 | 0.78 | 20.0 d | 64.3 | 3 | 11.0 c | 68.6 | 3 |
| Ox | 312.0 L | 85.1 | 0.16 | 4.25 h | 92.4 | 2 | 2.0 h | 94.3 | 1 |
| J+PS | 1126.0 e | 46.2 | 0.56 | 17.0 de | 69.6 | 3 | 10.0 d | 71.4 | 3 |
| J+BN | 1052.0 f | 49.8 | 0.53 | 14.0 f | 75.0 | 3 | 10.0 d | 71.4 | 2 |
| J+OX | 1034.0 g | 50.6 | 0.52 | 14.0 f | 75.0 | 3 | 9.0 e | 74.3 | 2 |
| PS+BN | 580.0 h | 72.3 | 0.29 | 12.0 g | 78.6 | 3 | 10.0 d | 71.4 | 2 |
| PS+OX | 442.0 i | 78.9 | 0.22 | 11.0 h | 80.4 | 3 | 9.0 e | 74.3 | 2 |
| J+PS+BN | 431.2 j | 79.4 | 0.22 | 10.25 i | 81.7 | 2 | 8.0 f | 77.1 | 2 |
| J+PS+OX | 380.0 k | 81.9 | 0.19 | 9.75 g | 82.6 | 2 | 6.0 g | 82.9 | 2 |
| N alone | 2093.6 a | --- | 1.05 | 56.0 a | -- | 5 | 35.0 a | -- | 5 |
| L.S.D | 4.010 | --- | | 3.301 | --- | --- | 3.291 | -- | -- |

**J=Jojoba oil; P= Potassium silicate; BN= Bio- Nematon OX=Oxamyl**
**N = 1200 ($J_{2s}$) of *M. incognita*** *** Each figure is the mean of three replicates**
**RF= Reproduction factor = final population/Initial population**

The data in Table (4) showed the efficacy of jojoba oil, potassium silicates, and Bio-Nematon, whether individually or in combination as a twofold or three-way treatment with oxamyl compared to oxamyl at the recommended rate on the nitrogen, phosphorus, and potassium content, total phenols, and total chlorophyll in the leaves of tomato plants infested with *M. incognita* under greenhouse conditions. It was obvious that the concentrations of N, P, and K significantly decreased due to nematode infestation. Interestingly, all tested treatments resulted in a significant increase in the concentrations of N, P, K, and total phenols that surpassed those of the nematodes alone (Table 4).

**Table 4.Photopigments, total phenols, and NPK components in fresh tomato leaves infected with *Meloidogyne incognita* and treated with three bioproducts individually or in integration.**

| Treatments | *Chemical components | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Leaves | | | | | | | | | Total phenol mg100g | Inc.% |
| | N% | P %. | K | C% | C / N | Chlorophyll content mg /g F.WT. | | | | | |
| | | | | | | Chlo. a | Chlo.a | a+b | Red.% | | |
| J | 1.65 | 0.456 | 1.91 | 35.40 | 1:21.5 | 0.647l | 0.478 l | 1.125 | 21.16 | 464.4 d | 6.92 |
| PS | 1.69 | 0.464 | 2.00 | 35.70 | 1:21.1 | 0.625m | 0.562 d | 1.187 | 16.82 | 472.1 e | 9.35 |
| BN | 1.74 | 0.480 | 2.00 | 36.00 | 1:20.7 | 0.655 j | 0.487 k | 1.142 | 19.97 | 479.8 d | 11.59 |
| OX | 1.87 | 0.483 | 2.28 | 36.50 | 1:19.5 | 0.666 i | 0.495 j | 1.161 | 18.64 | 432.7 h | 13.93 |
| J+PS | 1.91 | 0.496 | 2.36 | 36.90 | 1:19.3 | 0.681 h | 0.514 i | 1.195 | 16.26 | 449.6 g | 18.38 |
| J+BN | 1.94 | 0.499 | 2.45 | 37.20 | 1:19.2 | 0.691 g | 0.670 c | 1.361 | 4.63 | 457.2 f | 20.38 |
| J+OX | 1.94 | 0.517 | 2.54 | 37.50 | 1:19.3 | 0.692 f | 0.522 g | 1.214 | 14.93 | 415.3 j | 22.27 |
| PS+BN | 2.12 | 0.523 | 2.63 | 37.90 | 1:17.9 | 0.698 e | 0.533 h | 1.231 | 13.74 | 406.1 k | 24.30 |
| PS+OX | 2.35 | 0.541 | 2.80 | 38.00 | 1:16.2 | 0.699 d | 0.542 f | 1.241 | 13.03 | 495.9 a | 26.33 |
| J+PS+BN | 2.23 | 0.532 | 2.74 | 38.20 | 1:17.1 | 0.719 c | 0.550 e | 1.269 | 11.07 | 423.8 i | 29.91 |
| J+PS+OX | 2.47 | 0.556 | 2.90 | 39.00 | 1:15.8 | 0.737 b | 0.670 c | 1.407 | 1.40 | 493.4 b | 30.57 |
| N alone | 1.59 | 0.445 | 1.84 | 35.1 | 1:22.1 | 0.744 a | 0.683 b | 1.427 | ----- | 379.8 l | ---- |
| Plant free of any treatment. | 2.59 | 0.568 | 3.00 | 39.3 | 1:15.2 | 0.654 k | 0.591a | 1.31 | 8.39 | 487.2c | 28.28 |
| L.S.D | 0.30 | 0.10 | 0.40 | 0.50 | --- | 0.005 | 0.002 | | | 0.204 | |

**J=Jojoba oil; P= Potassium silicate; BN= Bio- Nematon OX=Oxamyl**
**N = 1200 ($J_{2s}$) of *M. incognita*** *** Each figure is the mean of three replicates**

Among the individual treatments, Bio-Nematon graded first in increasing the concentrations of N, P, K, and total phenols with values of 1.74, 0.480, 2.00, and 11.9%, respectively, followed by potassium silicate and then jojoba oil. At the same time, among the dual treatments, potassium silicate with oxamyl at half rate achieved the highest concentrations of N (2.35), P (0.541), K (2.80), and total phenols (495.9 mg/100g) (26.33%), followed by potassium silicate + Bio-Nematon.

Moreover, there was a significant increase in the concentrations of nitrogen, phosphorus, potassium, and total phenolic compounds when oxamyl was added to potassium silicate and jojoba oil at a rate of ⅓ each, with values of 2.47, 0.556, 2.90, and 30.57% respectively, alongside a low total chlorophyll content in the leaves of the tomato plant was recorded.

For the carbon to nitrogen ratio, it ranged from 20.7:1 to 21.50:1; 16.20:1 to 19.30:1, and 15.80:1 to 17.10:1 for the individual, dual, and tri-treatments, respectively. The carbon to nitrogen ratio for the tri-treatment was the lowest (15.8:1), while oxamyl was 19.5:1 and 22.1:1 for nematodes alone (Table 4).

In general, triple treatments including oxamyl, potassium silicate and jojoba oil at a rate of ⅓ each recorded better results than dual treatments, followed by individual treatments in improving tomato plant metrics and reducing nematode parameters. Individual treatments showed varying results, with the treatment using oxamyl achieving the best results in improving plant metrics, (plant height, plant weight, and dry weight). The triple treatment of jojoba oil with potassium silicate and the nematicide achieved the best results among all tested treatments, for the tested plant metrics as well as reducing the tested nematode metrics (number of juveniles in 250g soil, number of galls and egg masses).

Furthermore, there was a significant increase in the concentrations of nitrogen, phosphorus, potassium, and total phenolic compounds when oxamyl was added to potassium silicate and jojoba oil as a tri-treatment.

The inhibitory effect of the tested materials may be attributed to the presence of chemicals with nematicidal effect. These chemicals either influenced embryonic development or killed the eggs or dissolved the egg masses (Asif et al., 2013). Egyptian jojoba oil is composed of Eicosenyloleate (C-38, 7%), Eicosenyleicosenoate (C-40, 30%), Docosenyleicosenoate (C-42, 52%), Eicosenyldocosenoate (C-42, 9%) and Docosenyldocoseno ate (C-44, 2%). These components can improve the biological activities against the root knot nematodes (Shawky et al., 2010). As these oils have a high ability to dissolve the cytoplasmic membrane of filamentous cells, which affects their functional groups, which interferes with the protein composition of nematode enzymes (Knoblock et al., 1989). In addition, there are some scientific hypotheses related to the mechanisms of these vegetable oils, which help in changing the nature and decomposition of enzymes, as well as interfering with the electron flow in the respiratory chain of pest or with the phosphorylation of adenosine diphosphate (Konstantopoulou et al., 1994).

Potassium silicate has been shown to effectively manage *M.incognita*, by improving plant growth parameters and reducing nematode populations. Studies have demonstrated that foliar spraying of potassium silicate can increase cucumber plant parameters as well as suppress *M.incognita* population with values indicating a 0.2 rate of reproduction, (El-Sherif et al., 2016). Combination treatments, such as potassium silicate + furfural + albendazole, can provide even better results in ground cherry, with a 72.3% reduction in *M. incognita* $J_2$ populations (AboKora, 2021). Silicon (Si) considered as the second element after oxygen in the percentage of its presence in the earth's crust and reduces the toxic effect on plants caused by increased salinity; dehydration and exposure to heavy metals (Ye et al., 2013). Silicon increases the ability of plants to withstand temperatures and droughts; prevent the penetration of fungi, bacteria, and nematodes into the cortex of plants, as it is concentrated at the site of penetration of the pest and prevents it from income and thus reduce the incidence of diseases (Gad, 2019). It is considered to have a major role in increasing plant resistance to pests (Dannon and Wydra, 2004).

Potassium silicate functions by employing two mechanisms: a physical barrier and a physiological increase within plant tissues. When applied, silicon gathers and undergoes polymerization at the areas of infection, strengthening cell walls to resist infections (Sangster, 1970; Fawe et al., 2001).

## CONCLUSION

From our results, it can be concluded that, natural alternatives such as jojoba oil, potassium silicate, and Bio-Nematon had a positive impact on tomato vegetative growth parameters, plant vigor and tolerance as well as controlling root-knot nematode. Furthermore, such alternatives are safe and friendly to the environment, human and animal. and might be used in tomatoes production after further studies.

## REFERENCES


A.O.A.C. (1980). Official methods of analysis" Twelfth Ed. Published by the Association of Official Analytical chemists, Benjamin, France line station, Washington. Dc.

Abokora, M. (2021). Impact of ecological friendly treatments on *Meloidogyne incognita* infected ground cherry. Egyptian Journal of Agronematology, 20(2): 101-109.

Ahmed, M.F.; Rao, A.S.; Ahemad, S.R. and Ibrahim,M. (2012). Phytochemical studies and antioxidant activity of *Melia azedarach linn* leaves by DPPH scavenging. International Journal of Pharmaceutical Applications .3:(1) :271-276.

Asif, M.; Parihar, K.; Rehman, B.; Ganai, M.A and Siddiqui, M.A. (2013). Bio-efficacy of some leaf extracts on the inhibition of egg hatching and mortality of *Meloidogyne incognita*. Archives of Phytopathology and Plant Protection 47: 10151021.

Byrd, D.W.; T. Kirkpatrick and K.Barker. (1983). An improved technique for clearing and staining plant tissues for detection nematodes. Journal of Nematology, 15 (3): 142-143.

Dannon, E.A. and Wydra, K. (2004). Interaction between silicon amendment, bacterial wilt development and phenotype of *Ralstonia solanacearum* in tomato genotypes. Physiol. Mol. Plant Pathol. 64(5):233–243.

El-Nagdi, W.M.A. ( 2005). Comparative efficacy of aqueous jojoba dry leaves extract and jojoba&castor oil commercial product on the root-knot, *Meloidogyne incognita* infecting pepper plant. Egypt of Journal Agriculture Research. NRC 2 (1):425–437.

El-Nagdi, W.M.A.; Hafez, O.M. and Taha,R.A. (2017). Efficiency of jojoba oil and bio-nematicide on *Meloidogyne incognita* and performance of flame seedless grapevine cuttings. Special issue, Agric. EngInt: CIGR Journal Open access at http://www.cigrjournal.org, 118-124.

El-Nagdi, W.M.A; Ahmed,A.A;. Gehan H.S. Mahmoud,G.H .(2009). Evaluation of some medicinal plant oils and a nematicide for controlling virus-transmitted nematode and other nematodes on table grapes. Egyptian Journal of Horticulture. 36 (1) :47-69.

El-Saedy, M. A. M., Mokbel, A. A. and Hammad, S. E.(2014). Efficacy of plant oils and garlic cultivation on controlling *Meloidogyne incognita* infected tomato plants. Pakistan Journal of Nematology, 32:39-50.

El-Sherif A. G., S. B. Gad and S. M. Saadoon, (2016). Impact of Potassium silicate application on *Meloidogyne incognita* infecting cucumber plant under greenhouse conditions. Asian Journal of Nematology, 5: 1-7.

El-Sherif, A. G; Gad, S. B;. and Saadoon, S. M.(2015). Evaluation of calcium sulphate, potassium silicate and moringa dry leaf powder on *Meloidogyne incognita* infecting tomato plant with reference to N, P, K, total phenol and cholorophyll status under greenhouse condition. Asian journal of Nematology.7(4):30-38 .doi.org/10.5897/JEN2015.0125.

Fawe, A. ; Menzies;J. G. ; Chérif, M., and Bélanger, R. R. (2001). Silicon and disease resistance in dicotyledons. In Studies in plant science .8 : 159-169.

Gad, S. B. (2019). Efficacy of soaking cotton seeds within salicylic acid and potassium silicate on reducing reniform nematode infection. Arch. Phytopathol.Plant. Prot. 52 (15-16): 1149-1160.

Gomaa, E.E.G.; Esmaiel, N.M.; Salem,M.Z.M. and Gomaa ,S.E.(2016). In vitro screening for antimicrobial activity of some medicinal plant seed extracts. International Journal of Biotechnology. Wellness Indust., 54: 142152.

Goodey, J. B. (1957). Laboratory methods for work with plant and soil nematodes. Tech. Bull.no.2 Min. Agriculture Fish Ed. London pp.47.

Goodwin, T.W. (1965). In: Goodwin, T.W. (Ed.), Chemistry and Biochemistry of Plant pigments. Academic Press, London, UK.

Goswami, B.K. and Mittal,A. (2002). Effect of some fungal bioagents on root-knot nematode, *Meloidogyne incognita* infecting brinjal. Pakistan Journal of Nematology. 20: 55-59.

Hafez, O.M.; Taha,R.A. and El Nagdi,W.M.A. (2017). Assessing efficacy of jojoba crushed seed and oil cake on growth vigor, nutritional status of Superior grapevine cuttings and controlling the root knot nematode. Special Issue: AgriFood and Biomass Supply Chains. Agriculture Engineering International., CIGR J., 19 111117.

Ibrahim, D. S. S.1.; Ali, A.M. and Metwaly,H.A.(2019). Bio-management of citrus Nematode, *Tylenchulus semipenetrans* and dry root rot fungi, *Fusarium solani* under laboratory and field conditions . Egyptian Journal of Agronematology.18(2) :118-128 .

Ismail, A.; Abidin, N. B. M. and Tudin, R. (2009). Relationship between transformational leadership, empowerment and followers' performance: An empirical study in Malaysia. Revista Negotium. 13(5) : 5-22.

Ismail, H.I.; Chan, K.W.; Mariod, A.A. and Ismail, M. (2011). Phenolic content and antioxidant activity of cantaloupe (*Cucumis melo*) methanolic extracts. Food Chemistry. 119: 643-647.

Kaur, C. and Kapoor,H.C. (2001). Antioxidants in fruits and vegetables ± the millennium's health. International Journal of Food Science and Technology, 36: 703-725.

Khairy, D .(2021). Advanced studies on integrated management of root-knot and reniform nematodes parasitizing eggplant. Ph.D. Thesis, Fac. Agric, Mansoura Univ.pp.146.

Khairy, D; Refaei, A. and Mostafa, F.A.M. (2021). Management of *Meloidogyne incognita* infecting eggplant using moringa extracts, vermicompost, and two commercial bio-products. Egyptian Journal of Agronematology. 20 (1): 1–16. doi: 10.21608/ejaj.2021.134910.

Knoblock, K. ; Pauli, A. ; Iberl, B.; Weigand, H. and Weis, N. (1989). Antibacterial and antifungal properties of essential oil components. Journal of Essential Oil Research, 1: 119–128.

Konstantopoulou, I.; Vassilopoulou, L.; Mavraganitispidou, P. and Scouras, Z.G. (1994). Insecticidal effects of essential oils. A study of essential oils extracted from eleven Greek aromatic plants on Drosophila auroria. Experientia, 48: 616–619.

Metwally, W. E.; Khalil, A. E. and Mostafa, F.A.M. (2019). Biopesticides as eco-friendly alternatives for the management of root-knot nematode, *Meloidogyne incognita* on cowpea (*Vigna unguiculata* L.). Egyptian Journal of Agronematology.18(2) :129-145 .

Moreno-Pedraza A.; Gabriel, J.; Treutler, H.; Winkler, R and Vergara, F. (2019). Effects of water availability in the soil on tropane alkaloid production in cultivated *Datura stramonium*. Metabolites 9131.

Mostafa, I. (2023). Effect of some biocides and entomopathogenic nematodes on suppressing root-knot nematode. Al-Azhar Journal of Agricultural Research, 48(3) : 319-330.

Mostafa, M.A.;Mahmoud, N. B.;Abdelmoneim, E. A. and El-Sagheer,A.M.(2017).Plant essential oils as eco-friendly management tools for root knot nematode on cucumber plants .The Journal of Zoology Studies 4(1):01-05.

Sangster, A.G. (1970). Intracellular silica deposition in immature leaves in three species of the Gramineae. Annals of Botany. 34 (1970) : 245-257.

Sharf, H.R. ; Abbasi, R.M. andAmbreen, A. (2011): Study of efficacy of leaf extracts of some plants on germination and sporulation of fungi *Paecilomyces lilacinus*. Journal of Natural Product and Plant Resources, 1(4): 86-89

Shawky, Samaa M.; Khalil,A.E. and Soliman, Manal, M. (2010). Non chemical control of root-knot nematode; *Meloidogyne javanica* on peanut in Egypt. Zagazig Journal of Agricultural Research. 37 (1):185–206.

Sivakumar, T., Renganathan, P. B. P., & Sanjeevkumar, K. (2020). Bio efficacy of bio-nematon (*Paecilomyces lilacinus* 1.15% wp) against root-knot nematode (*Meloidogyne incognita*) in cucumber crop. Plant Arch, 20(2) : 3805-3810.

Taylor, A. L. and Sasser, J.N. (1978). Biology, identification and control of root-knot nematodes (*Meloidogyne* species). Raleigh, NC: North Carolina State University Graphics.

Wang, S.Y and Galletta, G.J. (1998). Foliar application of potassium silicate induces metabolic changes in strawberry plants. Journal of Plant Nutrition. 21(1):157-167.

Yang ,X.J.; Wang, X.; Wang, K.; Su ,L.X.; Li, H.M.; Li ,R. and Shen, Q.R. (2015). The nematicidal effect of camellia seed cake on root-knot nematode, *Meloidogyne javanica* of banana. PLoS ONE 10:119700.

Ye M.; Song Y.Y.; Long, J.; Wang, R.L.; Baerson, S.R. and Pan, Z.Q. (2013). Priming of jasmonate-mediated antiherbivore defense responses in rice by silicon. Proc. Natl. Acad. Sci. U.S.A. 110:3631–3639.

Yermanos, D. M. (1975). Omega-3 fatty acids: Keys to nutritional health. Journal of the American Oil Chemists, 43(9): 215–219.

# الكفاءة الابادية لزيت الجوجوبا وسيليكات البوتاسيوم وبيو-نيماتون بشكل فردي أو متكامل على الاصابة بنيماتودا *Meloidogyne incognita* تحت ظروف المعمل والصوبة الزراعية

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## الملخص

تم إجراء هذه الدراسة تحت ظروف المعمل والصوبة لتحديد النشاط الابادي لكلا من زيت الجوجوبا، وسيليكات البوتاسيوم، والمركب الحيوي بيونيماتون بشكل فردي أو مشترك على نيماتودا تعقد الجذور *M. incognita* وكانت النتائج كالتالي:1-سجلت جميع المعاملات زيادة ملحوظة (P≤0.05) في معدل موت يرقات *M. incognita* والذي يعتمد بدرجة اساسية علي نوع المعاملة ومدة التعرض حيث سجلت المعاملة الثلاثية أفضل النتائج، تليها المعاملة الثنائية، وأخيرًا المعاملات الفردية.1-حققت المعاملة الثلاثية بكلا من زيت الجوجوبا مع سيليكات البوتاسيوم والمبيد النيماتودى أفضل النتائج بين جميع المعاملات المختبرة بقيم 113.60%، 147.18%، و105.20% للمقاييس النباتية المختبرة ، طول النبات، وزن النبات، وزن المجموع الخضري على التوالي.2-سجلت نفس المعاملة الثلاثية أفضل النتائج بين جميع المعاملات المختبرة في تقليل المقاييس النيماتودية المختبرة بقيم 81.85، 82.59 و82.86%، لعدد اليرقات، العقد النيماتودية، وكتل البيض على التوالي.3- كان هناك زيادة ملحوظة في تركيزات النيتروجين، والفوسفور، والبوتاسيوم، والمركبات الفينولية الكلية بواسطة المعاملة الثلاثية بكلا من زيت الجوجوبا مع سيليكات البوتاسيوم والمبيد بقيم 2.47، 0.556، 2.90، و(30.57%) على التوالي، بينما انخفض محتوى الكلوروفيل الكلي في أوراق نبات الطماطم.