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Plant Extracts for Controlling *Meloidogyne incognita* Infected Tomato Plants Grown in Three Natural Soil Textures

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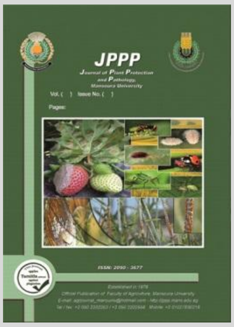

ABSTRACT

The efficacy of plant leaf extracts (*Ricinus communis* (Castor), *Anethum graveolens* (Dill), *Azadirachta indica* (Neem), and *Mentha arvensis* (Mint)) across three soil types (clay, loam, and sandy) in controlling *Meloidogyne incognita* infection in tomato plants cv. 888 was evaluated under greenhouse conditions, results indicate that all tested plant extracts enhanced tomato plant growth parameters while reducing nematode-related metrics, with variations observed based on soil types. Among the extracts, dill exhibited the highest nematode population reduction in both soil and root, achieving 83.7, 82.0, and 77.7 % reduction rates in sandy, loamy, and clay soils, respectively. Furthermore, the nematode reproduction factor was significantly suppressed by the tested aqueous leaf extracts (dill, castor, neem, mint) or krenkel across different soil textures. These values ranged from 0.25 to 1.24 in sandy soils, 0.39 to 1.01 in loamy soils, and 0.52 to 0.74 in clay soils, compared to control values of 3.18, 2.15, and 1.10 for the same soil types, respectively.

Keywords: *Meloidogyne incognita*; Plant Extracts; Soil; Tomato.

INTRODUCTION

Tomato (*Solanum lycopersicum*) is one of the most popular and widely consumed vegetables in the world, including Egypt (Abd El-Ghany, 2011). The fruit is rich in minerals such as potassium and sodium, proteins, citric acid, sugars, dietary fibers, and high levels of vitamins C, lycopene, and beta-carotene (Naika *et al.*, 2005). In Egypt, the total area under production reaches up to 143.618 ha, and the total output is estimated at 6.3 million metric tons (FAOSTAT, 2023). Poor yield of tomatoes in Egypt has been attributed in part to root-knot diseases caused by *Meloidogyne* spp. and cause great losses in tomato crops (Abd-Elgawad, 2014; Khalil *et al.*, 2022). Galling and the resulting reproduction of *Meloidogyne* spp. in the roots of infected plants significantly hinder the plant's ability to absorb water and nutrients. According to statistics from 2011-2012, plant-parasitic nematodes led to annual losses of $2.30 billion in Egyptian agriculture, with additional millions spent each year on efforts to mitigate their impact (Abd-Elgawad and Askary, 2015). This highlights an urgent need to adopt effective control measures to ensure stable yields and maintain profitable production.

Traditionally, the use of chemical nematicides was the main control technique; however, chemical nematicides have negative consequences for the environment as they are highly toxic to mammals and animals, pollute soil and groundwater, and have a residual effect on farm produce. In addition to its inefficiency after long-term use (Huang *et al.*, 2016). The use of plant extracts as part of integrated nematode management is rapidly gaining widespread acceptance. This approach is seen as an excellent alternative to chemical nematicides, offering a way to minimize harmful effects on both human health and the environment. Numerous plants are known to exhibit nematicidal properties, and the biological activity of many has been assessed against root-knot nematodes (Opender *et al.*, 2008). In particular, essential oils derived from the Apiaceae family have demonstrated significant nematicidal effects, making them promising substitutes for chemical and synthetic nematicides (Ebadollahi, 2013).

Castor (*Ricinus communis*) water extracts had high nematocidal activity, which contained a toxic enzyme called ricin (Gao *et al.*, 2011). Neem (*Azadirachta indica*) is an effective alternative against plant parasitic nematodes. The presence of certain biologically active compounds, such as azadirachtin, nimbin, kaempferol, and thionemone, has been documented for their nematicidal properties (Abbasi *et al.*, 2005; Khalil, 2013). Additionally, numerous pharmacological attributes of mint (*Mentha arvensis*) have been extensively investigated. These include analgesic, antiviral, antibacterial, antifungal, and antiparasitic activities (Štrbac *et al.*, 2023). Plant-parasitic nematodes, which are soil-dwelling pathogens, exhibit growth and pathogenic behavior that are significantly influenced by abiotic soil factors, including aeration, moisture, temperature, texture, and structure. These factors also play a pivotal role in determining nematode functionality (Van Gundy, 1985). Soil texture, characterized by the relative proportions of sand, silt, and clay particles, is a critical factor influencing soil compactness. This property significantly affects both aeration and moisture availability, which serve as foundational criteria for delineating management zones for plant-parasitic nematodes within agricultural fields (Moore and Lawrence, 2013). In light of this, the current study was designed to examine the impact of four plant-derived extracts - dill, castor, neem, and mint - on the infection caused by (*Meloidogyne incognita*) in tomato plants. The experiment was conducted under controlled greenhouse conditions (22±3ºC) across three

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natural soil textures to assess the interaction between soil type and nematode management strategies.

MATERIALS AND METHODS

Source of Nematodes

The root-knot nematode, *Meloidogyne incognita* (Eisenback, 1985), was utilized as the experimental pathogen for this study. Pure cultures of *M. incognita* were established using roots of *Coleus blumei* infected with single egg masses of the nematode. The infected plants were maintained in the greenhouse facilities of the Faculty of Agriculture, Damietta University, Egypt. Sterilized pots with a diameter of 15 cm were filled with a potting mixture composed of clay and sand in a 1:1 (v/v) ratio. The pots were placed on a sanitized bench within the greenhouse and provided with water and fertilizer as required. After two months, the coleus plants were uprooted, and their roots were inspected for signs of nematode infection. Infected roots served as inoculum for subsequent infestations of other coleus plants, ensuring continuous sub-culturing and propagation to maintain sufficient nematode populations for further experiments conducted in the greenhouse.

Nematode eggs were extracted from infected coleus roots following the maceration method using 0.5% (v/v) sodium hypochlorite (NaOCl), as described by Hussey and Barker (1973). The extracted eggs were then processed using Baermann trays (Whitehead and Hemming, 1965) to facilitate the collection of juvenile nematodes (J2s) required for subsequent experimental applications.

Nematicides:

Krenkel 75% EC, (RS)-S-sec-butyl-O-ethyl-2-oxo-1,3-thiazolidin-3-ylphosphono-thioate was used at the rate of 0.3 ml/plant as the recommended dose in this work.

Preparation of leaf plant extracts:

The following medicinal plant extracts i.e., *Ricinus communis* (Castor), *Anethum graveolens* (Dill), *Azadirachta indica* (Neem), and *Mentha arvensis* (Mint) were prepared by dissolving 5g of each plant powder in one liter of distilled water. Scientific names and used parts are presented in Table (1).

Table 1. English, scientific, family names and used part of botanical products as soil organic amendments.

No.	English name	Scientific name	Family name	Part used
1	Castor	*Ricinus communis*	Euphorbiaceae	Leaf
2	Dill	*Anethum graveolens*	Apiaceae	Leaf
3	Neem	*Azadirachta indica*	Meliaceae	Leaf
4	Mint	*Mentha arvensis*	Lamiaceae	Leaf

Greenhouse studies:

A greenhouse experiment was conducted to evaluate the nematicide properties of four botanical extracts i.e., castor, dill, neem, and mint as soil organic amendments in comparison with krenkel against *M. incognita* infecting tomato plant cv. 888 grown in three naturally soil textures. These three naturally soil textures *i.e.*, clayey, loamy, and sandy were obtained from three different counties of Dakahlia (Dikernis) and Damietta (Faraskour and Kafr El-Batikh) governorates and their mechanical and chemical analysis were recorded in Table (2).

Table 2. Mechanical and chemical analysis of three naturally soil type textures from three different counties of Damietta and Dakahlia governorates.

Name of County and Governorate	*Mechanical analysis %					*Chemical analysis					*Avail. ppm		
	C. Sand%	F. Sand%	Silt %	Clay %	T. Class	Sp %	PH 1:2.5	Ec 1:5ds /m	CaCo3 %	O.M %	N	P	K
Dikernis (Dakahlia)	1.85	12.66	32.39	53.10	Clayey	61	7.92	1.53	1.88	1.93	57.6	5.6	3.48
Faraskour(Damietta)	3.42	18.78	38.65	39.15	Loamy	42	8.05	1.06	2.97	1.42	43.5	3.9	2.94
Kafr El-Batikh(Damietta)	6.9	89.1	2.0	2.0	Sandy	26	7.78	0.92	4.12	0.56	22.3	3.2	1.85

*** Mechanical and chemical analysis of such soil types were conducted according to the method described by Chapman and Pratt (1961) and Jackson (1967).**
**** Ec. = Electrical conductivity in 1: 5 soils: water suspension, PH= Acidity in 1: 25 soils: water suspension.**

Twenty-eight plastic pots 15 cm-diam were filled with 1000 g steam-sterilizing soil type each. Each plastic pot was planted with one seedling of tomato plant (25 days–old) and received water as needed. Twenty-four seedlings were inoculated with 1500 J_2 each for each soil type under study. Screened plant extracts or krenkel nematicide were separately introduced at the rate of 5 ml /plant each for the four-plant extract as soil drenching and 0.3 ml/plant for Krenkel nematicide. All components were added to the soil of tomato seedling after a week of introducing the inoculate of *M. incognita* (N). Each treatment was replicated four times within each soil type texture. For each soil type, four plastic pots with one tomato seedlings each left with nematode only and served as positive control. Another four plastic pots with one tomato seedling each also left without nematode and any treatment to serve as negative control (Healthy plant). Treatments were as follows: 1- N+ Dill leaf extract; 2- N+ Castor leaf extract; 3- N+ Mint leaf extract; 4- N+ Neem leaf extract; 5- N+ Krenkel; 6- Nematode only and 7- Healthy plant.

Plastic pots were irrigated as needed and arranged in a randomized complete block design (RCBD), with all plants receiving uniform agronomic treatment under greenhouse conditions maintained at 22±3°C. Tomato plants were harvested 45 days after nematode inoculation. Plant growth characteristics and nematode parameters were assessed following previously described methods. Both statistical and chemical analyses were conducted as outlined earlier.

Chemical analysis:

Samples of dried leaves, ground and subjected to the specified treatment, were analyzed in their wet and digested forms to determine their nitrogen (N), phosphorus (P), and potassium (K) contents using the Kjeldahl method (A.O.A.C, 1980).

Chlorophyll content:

Samples from the upper fourth leaf were collected 40 days after sowing, and the chlorophyll a and b concentrations (mg/g F.W.) were measured. The pigment content was calculated using the equations established by Wellburn and Lichtenthalar (1984).

Data Analysis:

Nematode experimental data were analyzed with one-way analysis of variance (ANOVA). Comparisons of means were made with the Duncan's Multiple Range Test (Costat Software, 2005).

RESULTS AND DISCUSSION

Tomato plant growth

Changes in tomato plant growth parameters (plant length, total plant fresh and shoot dry weights) because of three soil textures i.e., sandy, loamy, and clayey accompanied with treating tomato seedlings by four aqueous leaf plant extracts in comparison with krenkel on controlling against *M. incognita* are presented (Table 3). The curative application of four plant extracts (castor, dill, neem, and mint) significantly promoted plant growth parameters than the control. Among tested treatments, the dill leaf extract treatment significantly surpassed all other applications in improving plant length, total plant fresh, and shoot dry weights, with increased percentage values of 26.4, 15.8, and 21.3%; 75.7, 68.9, and 72.2%; and 71.8, 54.1, and 70.3% for sandy, loamy, and clayey soil textures, respectively, compared to nematode alone. Maximum and higher shoot and root length; root and shoot fresh; and shoot dry weights, of tomato plants were obtained in clayey soil while these plant growth characters were minimum and remarkably lower in sandy soil except in certain cases as for castor in plant length, as affected by tested treatments. In each soil texture type, tomato growth parameters were observed to differ significantly between each treatment tested. It's important to note that healthy plants outperformed dill, neem, mint, and castor extracts for plant length (27.4%) in sandy soil. No significant differences were noticed between some treatments within each soil type and nematode alone regarding shoot and root lengths except in some cases, especially with dill or castor treatments compared to nematode and the untreated uninoculated plant.

Table 3. Plant growth response of tomato plants grown within three natural soil types infected with *M. incognita* under the stress of four aqueous leaf plant extracts under greenhouse conditions (22±3°C).

Treatments	*Plant growth response								Shoot Dry wt. (g)	Inc. %
	Length (cm)				Plant fresh wt.					
	Shoot	Root	Total	Inc.%	Shoot	Root	Total	Inc. %		
					Clayey soil (A)					
Castor extract	15.3ab	9.0a	24.3ab	12.8	8.7ab	1.5ab	10.2ab	62.5	1.4ab	57.9
Dill extract	17.33a	9.6a	26.9a	21.3	11.9a	1.9a	13.8a	72.2	1.9ab	70.3
Neem extract	15.0ab	8.0a	23.0ab	7.8	6.6bc	1.1bc	7.7bc	50.1	1.4ab	57.3
Mint extract	14.3ab	9.0a	23.3ab	9.9	6.6bc	0.6c	7.2bcd	46.8	1.3a	47.7
Krenkel	14.0b	9.0a	23.0ab	7.8	4.1c	0.7c	4.9cd	21.2	0.6b	4.9
Healthy plant	15.3ab	9.6a	24.9ab	14.9	5.6bc	0.4c	6.0cd	36.6	1.3ab	53.9
N alone	12.6b	8.6a	21.2b	----	3.3c	0.5c	3.8d	----	0.6b	----
					loamy soil (B)					
Castor extract	16.6ab	10.0a	26.6ab	17.7	7.3ab	0.7ab	8.0ab	51.8	1.5ab	53.4
Dill extract	16.0a	10.0a	26.0a	15.8	9.9a	3.7a	13.6a	68.9	1.5ab	54.1
Neem extract	14.0ab	8.5a	22.5ab	2.7	9.1bc	1.3bc	10.4bc	59.3	1.4ab	51.4
Mint extract	14.0ab	8.5a	22.5ab	2.7	4.7bc	1.1c	5.8bcd	27.2	1.0a	44.3
Krenkel	13.2ab	10.3a	23.5ab	6.8	4.5c	1.2c	5.7cd	25.9	0.7b	6.8
Healthy plant	15.0b	10.0a	25.0ab	12.4	6.3bc	1.2c	7.5cd	43.6	1.1ab	18.6
N alone	13.6b	8.3a	21.9b	----	3.3c	0.9c	4.2d	----	0.7b	----
					Sandy soil (C)					
Castor extract	15.0ab	9.0a	24.0ab	24.3	2.8ab	0.5ab	3.3ab	52.1	0.7ab	65.7
Dill extract	15.5a	9.2a	24.7a	26.4	5.6a	0.8a	6.4a	75.7	0.6ab	71.8
Neem extract	13.7ab	9.0a	22.7ab	19.9	2.0bc	0.9bc	2.9bc	45.3	0.6ab	62.9
Mint extract	14.0ab	7.0a	21.0ab	13.5	2.3bc	0.4c	2.7bcd	41.4	0.6a	60.3
Krenkel	11.3ab	8.7a	20.0ab	9.0	1.8c	0.4c	2.2cd	29.3	0.3b	30.3
Healthy plant	16.0b	9.0a	25.0ab	27.4	2.5bc	0.7c	3.2cd	51.1	0.4ab	48.9
N alone	11.2b	7.0a	18.2b	----	0.9c	0.7c	1.6d	----	0.3b	----

***Each value presented the mean of four replicates** **N = *M. incognita* (1500 juveniles/ plant) as the initial population.**
Means in each column followed the same letter(s) did not differ at p ≤ 0.05 according to Duncan`s multiple rang test.

Root and soil parameters

The treated pots showed a significant decrease (P ≤ 0.05) in root parameters (nematode population, root galling, and egg mass number). illustrated the impact of the integration between soil types i.e., clayey, loamy, and sandy, and the tested plant leaf extract, significantly decreased (P≤0.05) the number of nematode populations, root galling, and egg masses number to the positive control (Tables 4). The results indicate that all tested treatments led to a significant decrease in the nematode population, root galling, and egg masses number of *M. incognita*, depending on the soil type textures. Meanwhile, *M. incognita* reproduction in tomato plants was higher in sandy (3.18) soil than in other soil types followed by loamy (2.15), whereas the clayey soil gave the lowest rate of nematode reproduction (1.10), respectively. Among the tested applications, dill leaf extract achieved the highest reduction percentage of the nematode population in soil and root, with values of 83.7, 82.0, and 77.7% for sandy, loamy, and clayey soils, respectively. Moreover, for each soil type, dill leaf extract once again ranked second to krenkel in suppressing nematode population density in soil and roots of tomatoes. The values for krenkel; dill, castor, neem, and mint leaf extracts can be arranged in descending order as follows: 85.0, 83.7, 73.3, 71.6, and 61.1%; 87.3, 82.0, 61.2, 60.9 and 52.7%; and 85.3, 77.7, 66.8, 50.1 and 32.6% for sandy, loamy, and clayey soil textures, respectively comparing to nematode alone. Also, the reproduction factor of the nematode under the stress of the tested extracts *i.e.*, dill, castor, neem, and mint leaf extracts or krenkel were adversely affected according to soil types. Such rates ranged between 0.52 or 0.39 or 0.25 to 1.24 or 1.01 or 0.74 for sandy, loamy, or clayey soil textures, vs 3.18 or 2.15 or 1.10 for the same soil types, respectively. Dill leaf extract had the lowest rate of reproduction with values of 0.52, 0.39, and 0.25 for such soil types, followed by castor and neem extracts, while mint extract had the highest ones (1.24 and 1.01) for sandy and loamy soil textures, except that of clayey soil with value of 0.74.

Table 4. Development and reproduction of *M. incognita* infecting tomato plants grown within three natural soil types as controlled by four leaf plant extracts in comparison with krenkel under greenhouse conditions at 22±3°C.

Treatments	Soil (J_2)	Nematode population in Root: Females	Nematode population in Root: Developmental stages	Final population (Pf)	RF	Red %	No. of galls	Red %	No. of Egg-masses	Red %
				Clayey soil (A)						
Castor extract	488.7d	46.7e	12.0b	547.3d	0.46	66.8	38.2d	66.8	39.7bc	59.9
Dill extract	300.6e	52.6d	14.7b	368.0e	0.25	77.7	44.3d	61.5	34.5c	65.2
Neem extract	728.3c	81.7b	13.0b	823.0c	0.55	50.1	76.0b	33.9	63.3b	36.1
Mint extract	1036.3b	61.3c	15.0b	1112.7b	0.74	32.6	60.0c	47.8	54.2bc	45.3
Krenkel	208.4f	23.0f	11.0b	242.3f	0.26	85.3	22.0e	80.9	7.7c	92.2
N alone	1423.2a	128.0a	98.6a	1650.0a	1.10	----	115.0a	----	99.0a	----
				loamy soil (B)						
Castor extract	1144.7c	67.3d	36.0b	1248.0c	0.83	61.2	61.7bc	75.8	50.3c	60.7
Dill extract	467.0d	78.7c	32.6b	578.3d	0.39	82.0	76.7bc	69.9	61.0bc	52.3
Neem extract	1131.3c	94.3b	32.6b	1258.3c	0.84	60.9	92.7b	63.6	79.7b	37.7
Mint extract	1401.2b	90.7b	30.2b	1522.3b	1.01	52.7	88.3b	65.4	67.3bc	47.4
Krenkel	346.0e	36.3e	27.0b	409.3e	0.27	87.3	33.3c	86.9	9.0d	93.0
N alone	2857.7a	217.3a	143.0a	3218.0a	2.15	----	255.0a	----	128.0a	----
				Sandy soil (C)						
Castor extract	1169.3d	89.7b	12.7c	1271.7d	0.85	73.3	85.0d	65.2	80.0c	49.0
Dill extract	675.3e	87.7b	12.0c	775.0e	0.52	83.7	86.3d	64.6	70.3d	55.2
Neem extract	1231.7c	111.7b	12.3c	1355.7c	0.90	71.6	108.3bc	55.6	91.6b	41.7
Mint extract	1738.2b	102.0b	13.7c	1854.0b	1.24	61.1	97.3cd	60.1	89.7b	42.9
Krenkel	572.3f	119.0b	26.2b	717.7e	0.48	85.0	114.0b	53.3	14.0e	91.1
N alone	4183.4a	289.0a	296.4a	4768.8a	3.18	----	244.0a	----	157.0a	----

***Each value presented the mean of four replicates; N = *M. incognita* (1500 juveniles / plant) as the initial population; RF= final population (Pf) / initial population (Pi); Means in each column followed the same letter(s) did not differ at P≤0.05 according to Duncan`s multiple rang test.**

Chemical analysis and chlorophyll content

Chemical analysis reveals the percentage increase of N, P, and K and total chlorophyll in leaves of tomatoes grown in three soil type textures treated by four-leaf plant extracts in comparison with krenkel as affected by *M. incognita* infection. In general, all tested plant leaf extracts significantly increased percentage values of leaves parameters, i.e., N, P, and K; and total chlorophyll contents in all soil types under study, Krenkel as a nematicide surpassed all tested plant leaf extract in the values of percentage increase of N, P, and K as well as chlorophyll in the leaves of tomato comparing to nematode alone. Meanwhile, among the four-leaf plant extracts tested, dill leaf extract achieved the highest percentage increase in values of N, P, and K in leaves in all types of soil tested, followed by castor then neem extract treatments, whereas mint extract showed the lowest value of the tested elements. Moreover, the untreated and uninoculated tomato plants showed negative results in percentage decrease values of N, P, and K minerals as well as total chlorophyll in leaves that was pronounced in sandy soil more than the other two soil types in some cases compared to nematode alone.

The impact of four aqueous leaf extracts - dill, castor, neem, and mint - on the infection of *Meloidogyne incognita* affecting tomato plants grown in three different natural soil types under greenhouse conditions revealed that all tested extracts enhanced plant growth parameters while reducing nematode infection indicators. These findings align with Ram and Baheti (2004) observations, which highlighted the efficacy of neem, castor, and karanj products in promoting plant growth and suppressing nematode populations compared to untreated controls. Among the tested extracts, dill leaf extract proved to be the most effective in improving plant growth traits and reducing nematode gall formation and egg mass numbers. These results are supported by studies such as those by (Oka *et al.* (2000); Sharma and Tripathi (2006); Ibrahim *et al.* (2006); Melakeberhan *et al.* (2006); Abbas *et al.* (2009); Ibrahim and Traboulsi (2009)). Insecticidal and antimicrobial properties are present in the castor oil plant (*Ricinus communis*), a coarse tropical perennial that has been characterized by (Upasani *et al.*, 2003).

The pot experiment revealed that aqueous extracts of castor caused a significant reduction in the number of root-knot nematode juveniles, galls, and females. These findings are consistent with the observations of Alshalaby and Noweer (2003), who reported that castor extracts effectively reduced the total population of root-knot nematode juveniles in both roots and soil. According to Gommers *et al.* (1982), this effect may be attributed to substances released by the extract into the soil, which inhibit the nematodes' ability to penetrate plant roots.

Similarly, Azhar and Seddiqu (2007) noted that neem plant extracts were effective in reducing nematode populations in the soil. Fassuliotis (1985) documented a decrease in egg masses, female counts, and final larval populations in the soil, indicating neem leaf extract's potential to control root-knot nematodes in tomatoes. This aligns with the findings of Abid *et al.* (1995), who reported that neem application led to a reduced nematode population and galling index, resulting in improved plant growth compared to untreated plants. Yasmin *et al.* (2003) also demonstrated that neem seed, leaf, and bark extracts could significantly suppress the root galling index and lower populations of *M. javanica* juveniles in sweet gourd.

In the field of agriculture, the composition and diversity of nematode communities significantly contribute to regulating soil processes and functions (Yeates, 2003). The establishment and distribution of these communities are shaped by a combination of abiotic and biotic factors. Plant-parasitic nematodes, for instance, are primarily aerobic organisms with aquatic origins, depending on adequate moisture levels and oxygen availability from thin soil water films. Optimal conditions for their survival generally fall within soil moisture levels of 40–60% of field capacity (Kim, 2015). Past studies have demonstrated that soil organic matter (OM) is inversely correlated with the prevalence of plant-parasitic nematodes, indicating that the introduction of organic compounds could be an effective strategy for suppressing these parasites (Barros *et al.,* 2017). Conversely, higher OM content facilitates the proliferation of free-living nematodes, linked to the enhanced growth of soil microbes, including bacteria and fungi, which serve as their primary food sources (Berry *et al.,* 2005). Consequently, soil OM emerges as a key determinant in shaping microphagous nematode populations (Pen-Mouratov *et al.,* 2010) while also influencing their spatial distribution within the soil (Cadet and Spaull, 2003). Additionally, when supplemented with nutrients and exhibiting a low carbon-to-nitrogen ratio, soil OM can significantly bolster bacteriophage nematode densities (Berg and Bengtsson, 2007).

Table 5. Increase or decrease percentage of nitrogen, phosphorus, and potassium concentrations as well as total chlorophyll content in leaves of tomato plants grown in three soil type textures treated by four plant leaf extracts under the infection of *M. incognita* infections in the greenhouse conditions at 22 ±3°c.

Characters	Chemical analysis						Chlorophyll, Mg/g F. W			
Treatments	N	Inc. %	P	Inc. %	K	Inc. %	A	B	A+B	Inc. %
Clayey soil (A)										
Castor extract	4.28	18.2	0.296	18.4	4.05	16.7	1.052	0.760	1.812	5.0
Dill extract	4.44	22.7	0.305	22.0	4.17	20.2	1.068	0.771	1.839	6.5
Neem extract	4.1	13.3	0.286	14.4	3.92	13.0	1.039	0. 751	1.790	3.7
Mint extract	3.93	8.6	0.275	10.0	3.78	8.9	1.024	0.743	1.767	2.4
Krenkel	3.77	4.1	0.263	5.2	3.63	4.6	1.009	0.773	1.782	3.2
Healthy plant	4.54	25.4	0.314	25.6	4.29	23.6	1.081	0.779	1.860	7.8
N alone	3.62	----	0.25	----	3.47	----	0.995	0.731	1.726	----
loamy soil (b)										
Castor extract	3.31	19.9	0.244	19.6	3.16	15.3	0.977	0.630	1.607	8.1
Dill extract	3.36	21.7	0.249	22.1	3.33	21.5	0.951	0.639	1.590	6.9
Neem extract	3.13	13.4	0.229	12.3	3.18	16.1	0.969	0.619	1.588	6.8
Mint extract	2.99	8.3	0.223	9.3	2.94	7.3	1.004	0.604	1.608	8.1
Krenkel	2.97	7.6	0.211	3.4	2.91	6.2	0.993	0.633	1.626	9.3
Healthy plant	3.45	25.0	0.255	25.0	3.37	23.0	1.002	0.653	1.655	11.3
N alone	2.76	----	0.204	----	2.74	----	0.926	0.561	1.487	----
Sandy soil (c)										
Castor extract	3.68	19.9	0.267	18.7	3.54	16.1	0.997	0.687	1.684	4.9
Dill extract	3.69	20.2	0.276	22.7	3.67	20.3	1.012	0.693	1.705	6.2
Neem extract	3.44	12.1	0.259	15.1	3.56	16.7	0.991	0.675	1.666	3.7
Mint extract	3.22	4.9	0.249	10.7	3.29	7.9	0.975	0.664	1.639	2.1
Krenkel	3.20	4.2	0.233	3.6	3.22	5.6	0.962	0.689	1.651	2.8
Healthy plant	3.76	22.5	0.281	24.9	3.73	22.3	1.029	0.706	1.735	8.0
N alone	3.07	----	0.225	----	3.05	----	0.945	0.661	1.606	----

***Each value presented the mean of four replicates   N = *M. incognita* (1500 juveniles/ plant) as the initial population**

% Decrease or Increase of each number = $\frac{\text{Treatment – N alone}}{\text{N alone}}$ ×100.

In this study, an increase in root galling and egg mass production of *Meloidogyne incognita* was observed in sandy soils. Light sandy soils are generally more conducive to large nematode populations compared to heavy clay soils due to their superior aeration properties, resulting from their coarse particulate structure. However, this advantage comes at a cost, as plants cultivated in sandy soils are more prone to water stress caused by rapid water drainage, which exacerbates nematode-induced damage (Dropkin, 1980). Moreover, *M. incognita* displays a distinct preference for soils with elevated sand content (Koenning *et al.,* 1996).

The study further explored the nematicidal potential of various abiotic factors, including plant leaf extracts used as biofertilizers, in managing *M. incognita* in tomatoes grown in soils with different textural properties. These materials were compared to conventional nematicides with results varying based on the chemical composition of the applied substances and the methodologies employed. The findings suggest that such bio-based treatments offer advantages in terms of safety and cost-effectiveness, presenting a viable alternative to synthetic nematicides under appropriate conditions.

CONCLUSION

The results of this study reveal that the use of botanical extracts (dill, castor, mint, and neem) was able to decrease the nematode population, reduce root galling, and increase tomato plant growth parameters. The botanical extracts can therefore serve as alternative to synthetic nematicides. also, the development and infestation of *M. incognita* vary critically depending on the soil texture.

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المستخلصات النباتية في مكافحة نيماتودا تعقد الجذور *Meloidogyne incognita* التي تصيب نباتات الطماطم المنزرعة في ثلاثة أنواع تربة مختلفة.

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الملخص

تمت هذه الدراسة باستخدام أربع مستخلصات نباتية هم (الشبت، الخروع، النيم والنعناع) كإضافة للتربة، لمكافحة نيماتودا تعقد الجذور *M. incognita* التي تصيب نباتات الطماطم صنف ٨٨٨ التي زرعت في ثلاث أنواع مختلفة من التربة وهى (تربة طينية – تربة طميية – تربة رملية) تحت ظروف الصوبة السلكية. ولقد أوضحت النتائج ما يلى: إن كل المستخلصات النباتية المختبرة قد أدت إلى إنخفاض كبير في عدد النيماتودا النهائي، وعدد العقد، وعدد كتل البيض وفقًا لقوام نوع التربة. في حين كان معامل تكاثر النيماتودا على نباتات الطماطم أعلى في التربة الرملية من أنواع التربة الأخرى بقيمة (٣,١٨) تليها التربة الطميية (٢,١٥) بينما أعطت التربة الطينية أقل معدل لتكاثر للنيماتودا (١,١٠) على التوالي. كما أوضحت النتائج أيضاً أن المستخلص الورقي للشبت قد أعطي أعلى نسبة خفض في أعداد النيماتودا النهائي وعدد العقد وكتل البيض بقيمة ٨٣,٧ و٨٢,٠ و٧٧,٧٪ للتربة الرملية والطميية والطينية على التوالي. كما سجل المستخلص الورقي للشبت أقل معدل تكاثر النيماتودا في جميع أنواع التربة بقيم ٠,٥٢ و٠,٣٩ و٠,٢٥ للتربة الرملية والطميية والطينية على التوالي، يليه مستخلص الخروع والنيم، بينما كان المستخلص الورقى للنعناع أعلى معدل تكاثر (١,٢٤ و ١,٠١ و٠,٧٤) لقوام التربة الرملية والطميية والطينية على التوالي.علاوه على ذلك تفوقت معاملة مستخلص الشبت بشكل كبير على جميع المعاملات الأخرى في تحسين طول النبات، والوزن الكلي للنبات الرطب والوزن الجاف للنباتات بنسبة زيادة نسبتها ٢٦,٤ و١٥,٨ و٢١,٣٪، ٧٥,٧ و٦٨,٩ و٧٢,٢٪؛ و٧١,٨ و٥٤,١ و٧٠,٣٪ لقوام التربة الرملية والطميية والطينية على التوالي مقارنة بالنيماتودا وحدها. كما أدت هذه المعاملة بمستخلص الشبت في زيادة نسب تركيز النيتروجين والفوسفور والبوتاسيوم.