Journal of Plant Protection and Pathology

Journal homepage & Available online at: www.jppp.journals.ekb.eg

Effectiveness of Three Botanical Dried Leaf Powders on Reproduction of Root-Knot Nematode, *Meloidogyne incognita* under Greenhouse Conditions

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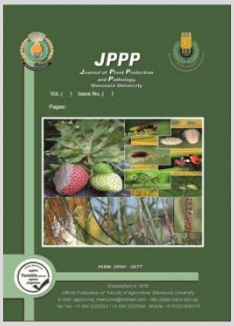

ABSTRACT

The effect of three dried leaf plant powders of *Trigonella foenum- graecum*, *Tagetes erecta* and *Capsicum annuum* singly or integrated with oxamyl on the reproduction of root-knot nematode, *Meloidogyne incognita* infecting tomato, *Solanum lycopersicum* was studied under greenhouse conditions. Dried leaf powder of *T. foenum-graecum* outperformed other single treatments tested for whole plant vegetation parameters. However, tetra application including such dried materials plus oxamyl showed a high synergistic effect on reducing nematode population, galls and egg masses numbers in tomato with values of 91.5, 92.5 and 94.8%, respectively. The chlorophyll content of the individual applications showed percentage reduction values in tomato leaves ranging from 14.1 to 16.6%, while the tetra treatment achieved the highest percentage reduction (18.1%). However, a significant increase in the concentration of nitrogen, phosphorus, potassium, and phenol was recorded with all tested treatments compared to nematode alone, Hence, the tetra treatment achieved the highest percentage in such criteria reaching 2.30, 0.44, 2.79 and 93.40%, respectively.

Keywords: Solanum lycopersicum, Meloidogyne incognita, Trigonella foenum- graecum, Tagetes erecta, Capsicum annuum.

INTRODUCTION

Tomatoes (*Solanum lycopersicum* L.) are a major component of regular meals in many countries and constitute an exceptional source of health-promoting compounds due teeo their balanced combination of minerals and antioxidants. The most widespread and damaging agricultural nematode pest is the root-knot nematode, *Meloidogyne incognita*. that causes significant expected damage worldwide (Oka et al., 2000). Meanwhile, aprominent losses in Egyptian vegetable crops during the last two decades were stated by nematode infection. Nematode control has been based on the use of harmful nematicides. The hope of creating a new environmentally friendly strategy for nematode management is a must. Many secondary metabolites are known to protect plants from several pests and pathogens such as alkaloids, glycosides, and flavonoids. A safe alternative strategy by botanical pesticides for nematode control may be for biodegradation and selective toxicity (Archana and Prasad, 2014). Plant materials are used for their nematicidal properties and reported a toxic to plant-parasitic nematodes (Zia et al., 2001; Ismail, 2013 and Umar and Ngwamdai, 2015). *Trigonella foenum-graecum* L. (Fenugreek) is known to have hypoglycemic, gastrointestinal tonic, antioxidant as well as liver protective effects (Srinivasan, 2006). Marigolds (*Amaranth* sp.) can be highly toxic to plant-parasitic nematodes and can kill a wide nematode pest depending on the type and cultivar of amaranth (Wanga et al., 2007). Peppers contain vitamins such as vitamins A, E, and C, and alkaloids such as capsaicin that have nematicidal activity (Neves et al., 2009).

The effect of three dried leaf plant powders, *Trigonella foenum- graecum*, *Tagetes erecta* and *Capsicum annuum*, singly or combined in double, triple or plus oxamyl form as quadruple application on tomato plant growth parameters and the root-knot nematode, *M. incognita* reproduction was studied.

MATERIALS AND METHODS

Preparation of nematodes inocula:

A pure culture of *Meloidogyne incognita* second stage (J_{2s}) started with one egg mass and maintained on coleus plants, *Coleus blumei*. The second stage of *M. incognita* inoculum (J2) was prepared by extracting it from the soil of infected coleus roots by screening modified according to Baermann technique (Goodey, 1957).

Preparing the aqueous extract:

Twenty-five grams of thoroughly leaves washed and chopped of three previously defined botanically, *Trigonella foenum- graecum, Tagetes erecta* and *Capsicum annuum* were separately sun dried then grinded and kept in a close container until use

Experimental Design

Sixty-four plastic pots (10cm-diam). containing 900 g steam sterilized sand loamy soil (1:1, v:v) with one seedlings 30 day-old of tomato, *Solanum lycopersicum* cv. 9065 to determine the effect of three botanical dry leaf powders i.e. *Trigonella foenum- graecum* , *Tagetes erecta* and *Capsicum annuum* as individual or integrated (dual or triple or tetra application) on reproduction of root-knot nematode, *M. incognita* under greenhouse conditions. Seven days after tomato seedlings transplanting, 2000 J2s of *M. incognita* were inoculated to sixty seedlings each and left four pots without

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DOI: 10.21608/jppp.2024.296621.1240

nematode to serve as check. One week later, the tested three botanical leaf powders were introduced to tested seedlings and mixed with soil rendering to design of experimental while four pots with nematode only were left without any treatment. Each treatment was replicated four times. The single treatments were *T. erecta*, *C. annuum* and *T. foenum-graecum* dry leaf powder (5g / pot each)}, Oxamyl (0.3ml /plant) and nematode alone. The binary applications were {½ *T. foenum- graecum* + ½ *C. annuum* (2.5g)}, {½ *T. erecta* + ½*C. annuum* (2.5g)} and {½ *T. foenum- graecum* + ½ *T. erecta* (2.5g)}. The triple applications were {⅓ *T.erecta* +⅓ *T. foenum- graecum* + ⅓ oxamyl (0.1mL/plant)}and {⅓ *C. annuum*+ ⅓ *T. foenum- graecum* + ⅓ oxamyl(0.1ml/plant)}, {⅓ *C. annuum*+ ⅓ *T. erecta* + ⅓ oxmyl(0.1mL/plant)}, {⅓ *T. erecta*+ ⅓ *T. foenum-graecum* + ⅓ *C. annuum* (1.6)}. The tetra application was {¼ oxamyl(0.75)+ ¼ *T. erecta*(1.25)+ ¼ *C. annuum*(1.25)+ ¼ *T. foenum -graecum* (1.25)}, and left four pots as healthy plants. Plants were harvested 45 days after nematode inoculation, plant growth parameters such as shoot and root lengths, fresh weights as well as shoot dry weights were determined and recorded. Number of *M. incognita* (J_{2s}) in 250 g. soil/pot was extracted by sieving and a modified Baermann technique (Goodey, 1957) and recorded. Root galls and egg masses indices were recorded on a scale of 0-5 according to the scale given by Taylor and Sasser (1978).

Chemical analysis

NPK and Chlorophyll content

Nitrogen (N), phosphorus (P) and potassium (K) contents in samples of grinded, wet and digested dried leaves were evaluated corresponding for Kjeldall methods (A.O.A.C, 1980) as well as chlorophyll a and b were determined according to Goodwin (1965).

Phenols

Phenols were determined by the Folin-Ciocalteau reagent (Kaur and Kapoor 2001) .

Data Analysis

Obtained data were subjected to analysis of variance (ANOVA) (Gomez and Gomez, 1984) followed by Duncan multiple ranges to compare means (Duncan, 1955).

RESULTS AND DISCUSSION

Results

Data in Table (1) demonstrate the effect of dry leaf powder of *T. erecta*, *C. annuum*, or *T. foenum- graecum* singly or mixed against *M. incognita* that infects tomato plants. The tested treatments enhanced plant vegetation parameters and decreased nematode indicators to different degrees. Between specific applications, the *T. foenum -graecum* outstripped other treatments in tomato growth standards i.e whole plant height (57.8%), number of leaves (13.3%) number of branches per plant (28.6%), whole plant fresh weight (41.1%) and shoot dry weight (40.0%). Then followed by *T. erecta* in this regard. Moreover, among the binary treatments tested, *T. foenum- graecum* plus *T. erecta* at half doses outstripped the other ones in terms of percentage increase in the values of whole plant length (94.2%), number of leaves (55.5%), number of branches (60.7%), whole fresh weight (70.7%) and shoot dry weight (80.0%), followed by ½ (*T. erecta* + *C. annuum*) and then ½ (*T. foenum -graecum* + *C. annuum*) in that order.

Table 1. Impact of dried leaf powder of *Tagetes erecta, Capsicum annuum or Trigonella foenum- graecum* on tomato growth response as affected by *Meloidogyne incognita* infection.

Treatments	*Plant growth response													
	Length (cm)		Plant length (cm)	**Inc.%	No. of leaves/ plant	**Inc.%	No.of branches/ plant	**Inc.%	Plant fresh weight(g)		Total Plant f.wt (g)	**Inc.%	Shoot dry weigh (g)	**Inc.%
	Shoot	Root							Shoot	Root				
Capsicum annuum	53.0 f	20.2 g	73.2 h	40.1	50.0 fg	11.1	8.0 ef	14.2	12.5 f	4.4 e	16.9 f	26.1	2.9 f	17.2
Tagetes erecta	59.6 e	22.2 f	81.8 g	56.6	50.5 fg	12.2	8.5 d-f	21.4	13.0 f	4.1 e	17.1 f	27.7	3.0 f	22.0
Trigonella foenum -graecum	57.8 e	24.6 e	82.4 g	57.8	51.0 f	13.3	9.0 c-f	28.6	14.5 ef	4.4 e	18.9 ef	41.1	3.5 e	40.0
½ (T. foenum -graecum +C. annuum)	68.5 d	26.2 d	94.7 f	81.3	57.0 e	26.6	10.0 b-e	42.8	15.0 ef	5.2 cd	20.2 de	50.8	3.9 d	56.4
½ (T. erecta +C. annuum)	72.0 d	22.9f	94.9 f	81.5	65.3 c	45.1	10.3 b-e	47.1	16.0 e	5.9 b	21.9 cd	63.4	4.0 d	63.2
½(T. foenum -graecum + T. erecta)	69.4 d	32.0 b	101.5e	94.2	70.0 b	55.5	11.2 bc	60.7	17.0 de	5.9 b	22.9 bc	70.7	4.5 c	80.0
⅓ (T. erecta+ T. foenum -graecum + Ox)	87.7 b	29.5 c	117.2b	124.2	72.8 ab	61.6	11.7 b	67.8	22.2 b	5.9 b	28.2 a	110.1	5.1 b	105.2
⅓ (C. annuum + T. foenum- graecum+ Ox)	83.5 b	30.0 c	113.5 bc	117.2	70.0 b	55.5	10.7 b-d	53.5	19.8 bc	5.5 bcd	25.3 b	88.7	4.5 c	82.8
⅓ (C. annuum + T. erecta + Ox)	85.0 b	24.8 e	109.8 cd	110.1	66.0 c	46.6	11.0 b-d	57.1	20.0 bc	5.7 bc	25.7 b	92.1	4.6 c	87.2
⅓(C. annuum + T. foenum graecum + T. erecta)	87.2 b	23.2f	107.5 d	111.4	72.8 ab	61.6	12.0 b	71.4	21.9 b	6.7 a	28.6 a	113.2	5.3 ab	114.8
¼(C.annuum+T. foenum-graecum+T.erecta+Ox	95.0 a	34.0 a	129.0 a	146.8	75.0 a	66.6	15.0 a	114.2	25.0 a	5.4 b-d	30.4 a	127.0	5.5a	122.8
Oxamyl (Ox)	75.9 c	25.2 de	101.1 e	93.6	60.6 d	34.6	9.0 c-f	28.5	18.9 cd	5.0 d	23.9 bc	78.5	4.5 c	81.2
N alone	36.0 h	16.2 i	52.2 j	—	45.0 h	_	7.0 f	_	10.0 g	3.4 f	13.4 g	_—	2.5 g	_
Healthy plant	40.0 g	19.0h	59.0i	12.8	47.0gh	4.4	7.5 f	7.1	10.0 g	4.0 e	14.0 g	4.3	2.7 fg	8.0
LSD	3.46	1.05	4.07	—	2.95		1.61		2.02	0.41	2.20		0.34	

N = 2000 (J_{2s}) of *M. incognita* Ox=Oxamyl * Each figure is the mean of four 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.

Likewise, a positive synergistic effect occurred on tomato plant growth as the three tested elements *T.erecta* plus *T. foenum- graecum* and Oxamyl were added at a ratio of ⅓ each with percentages of increase 124.2% , 61.6%, and 67.8% 110.1%, and 105.2%, in whole plant height, number of leaves, number of branches, fresh weight of whole plant and shoot dry weight, respectively.

Quadruple treatment (*C. annuum* + *T. foenum-graecum* + *T. erecta* + oxamyl) passed a high synergistic effect reaching highest values in tomato plant growth (146.8, 66.6, 114.2, 127.0% and 122.8%) for plant height, number of leaves and shoots, whole fresh weight and shoot dry weight, respectively. Oxamyl achieved excellent results, with values reaching 93.6, 34.6, 28.5, 78.5 and 81.2% for such previous criteria, respectively.

Data in Table (2) revealed the effect of *T. erecta*, *C. annuum* and *T. foenum- graecum* applications either alone or mixed on reproduction of *M. incognita* infecting tomato plants. Overall, results indicated that all treatments clearly reduced *M. incognita* parameters such as juveniles number in soil, development stages, root galls, females and egg masses numbers on tomato root system. The dual, triple or quadruple treatments afforded enhanced results than did individual ones. Among individual applications, *T. foenum- graecum* dry leaf powder sustained the top percentage decrease in nematode parameters (18.7, 75.6, and 77.7%) for nematode final population, galls, and egg masses numbers, respectively.

Furthermore, *T. erecta* stated second to *T. foenum-graecum* dried leaf powder in reducing nematode parameters (17.6, 72.2 and 75.5%) for such previous criteria, respectively. Whereas, *C. annuum* showed the lowest values in this regard, (5.6, 65.2 and 74.0%) for the final nematode, galls and egg masses numbers, respectively compared to the check. Regarding dual applications, *T. foenum- graecum* plus *T. erecta* at half rates completed the highest decline values in final nematode population (46.9%), galls (83.3%), and egg masses (85.1%) numbers.

A clear synergistic effect of triple application was evident resulting in a higher percentage reduction in nematode parameters. Plants receiving a treatment containing ⅓ (*T. foenum- graecum* + *T. erecta* + oxamyl) outperformed the other triple treatments tested in reducing final nematode population (77.5%), galls (88.9%), and egg masses (88.9%) numbers, followed by ⅓ (*C. annuum* + *T. erecta* + oxamyl). However, plants received the three dried leaf powders tested as a triple treatment without oxamyl gave significant percentage reductions in final nematode population (85.2%), galls (91.6%), and egg masses (92.5%) numbers. Moreover, quadruple submission including the three materials plus oxamyl a clearly recorded high synergistic effect on reducing final nematode population, number of galls and egg masses (91.5, 92.5 and 94.8%), respectively.

It is worth noting that Oxamyl ranked first as it achieved the highest percentage of reduction in the final nematode population (93.5%), galls (97.0%), and egg masses (98.5%) numbers. The nematode reproduction factors rates under the pressure of dry leaf powders of *C. annuum, T. erecta* and *T. foenum -graecum* singly or integrated ranged between 0.2 and 0.9 compared to 2.4 for nematodes alone. The quadruple application had the lowest reproduction rate of 0.2 while single application of *C. annuum* showed the highest rate 0.9, and oxamyl sustained the lowest value (0.1) in this regard.

Table 2. The root-knot nematode criteria on tomato plant as affected by *Tagetes erecta* or *Capsicum annuum* or *Trigonella foenum- graecum* dried leaf powders under greenhouse condition.

Treatments	Nematode parameters *												
	Nematode population in			Final population (Pf)	Red. %	RF	No. galls	Red. %	RGI	No .-egg masses	Red.%	EI
	Soil (J2s)	Root										
		Females	Dev. Stages									
Capsicum annuum	1800.0 b	37.0 b	51.0 b	1888.0 b	5.6	0.9	50.0 b	65.2	4.0	35.0 b	74.0	4.0
Tagetes erecta	1578.0 c	35.0 bc	34.2 d	1647.2 c	17.6	0.8	40.0 c	72.2	4.0	33.0 bc	75.5	4.0
Trigonella foenum -graecum	1561.2d	32.5 c	32.0 d	1625.7 d	18.7	0.8	35.0 d	75.6	4.0	30.0 c	77.7	4.0
½ (T. foenum -graecum +C. annuum)	1136.0 e	36.2 b	42.0 c	1214.2 e	39.3	0.6	37.0 cd	74.3	4.0	25.0 d	81.4	3.0
½ (T. erecta +C. annuum)	1032.0 f	27.0 d	29.5 e	1088.5 f	45.6	0.5	34.0 d	76.3	4.0	24.0 d	82.2	3.0
½(T. foenum -graecum + T. erecta)	1024.0 g	27.2 d	9.7 g	1060.7 g	46.9	0.5	24.0 e	83.3	3.0	20.0 e	85.1	3.0
⅓ (T. erecta+ T. foenum -graecum + Ox)	420.0 j	15.0 f	10.0 g	450.0 k	77.5	0.2	16.0 f	88.9	3.0	9.0 f	88.9	2.0
⅓ (C. annuum + T. foenum- graecum+ Ox)	422.0 j	19.0 e	17.5 f	458.5 j	77.1	0.2	18.0 f	87.5	3.0	10.0 f	92.5	2.0
⅓ (C. annuum + T. erecta + Ox)	481.2 i	17.5 ef	10.2 g	508.2 i	74.5	0.2	12.2 g	91.4	3.0	10.0 f	92.5	2.0
⅓(C. annuum + T. foenum graecum + T. erecta)	590.0 h	15.2 f	11.5 g	616.7 h	85.2	0.3	12.0 g	91.6	3.0	10.0 f	92.5	2.0
¼(C. annuum +T. foenum- graecum + T. erecta +Ox	400.0 k	8.5 g	4.2 h	412.7 l	91.5	0.2	10.7 g	92.5	2.0	7.0 f	94.8	2.0
Oxamyl (Ox)	312.0 L	1.5 h	2.2 h	315.7 m	93.5	0.1	4.2 h	97.0	2.0	2.0 g	98.5	1.0
N alone	4593.6 a	150.5 a	122.0 a	4866.1 a	_	2.4	144.0 a	_	5.0	135.0 a	_	5.0
LSD	4.01	2.64	2.31	6.92			3.30			3.29		

N = 2000 (J_{2s}) of *M. incognita* Ox=Oxamyl * Each figure is the mean of four replicates .RGI = Root galls index EI= egg masses index
***Means in each column followed by the same letter(s) did not differ at p<0.05 according to Duncan's multiple-range test.**

The data in Table (3) showed the effect of *T. erecta* or *C. annuum* or *T. foenum -graecum* as dry leaf powders alone or mixed on nitrogen, phosphorus, potassium, whole phenol, and whole chlorophyll in tomato leaves infected with *M. incognita*. It was evident that the concentration of N, P and K had apparently deteriorated due to nematode invasion. Interestingly, all treatments tested gave a significant increase in the concentration of N, P, K and phenol beyond that of the nematode alone. Between the individual treatments, *T. foenum-graecum* performed the best in increasing N, P, K and whole phenol concentrations (1.60, 0.37, 1.90 and 20.8%), followed by *T. erecta* and *C. annuum*, respectively.

Meanwhile, among the binary treatments, *T. foenum-graecum* + *T. erecta* at half rate achieved the highest concentrations with values 1.80, 0.38, 2.20 and 16.1 for N, P, K and whole phenol, followed by *T. erecta* + *C. annuum* then *T. foenum- graecum* + *C. annuum*.

Moreover, a clear synergistic action in N, P and K concentrations occurred when oxamyl was added with *C. annuum* + *T. erecta* . A great synergistic effect was also marked with the quadruple application increasing the concentrations of 2.30%, 0.44%, 2.79% and 23.7% for N, P, K and phenols which exceeded all treatments in this regard.

As for the entire chlorophyll content, single application of dry leaf powder of tested materials showed a percentage of reduction ranged from 14.1 to 16.6 %, while quadruple treatment achieved the highest decrease in the full chlorophyll content (18.1 %) compared to nematodes alone. Data in Table (3) also showed that dried leaf powder of tested materials singly or in combination with oxamyl revealed a C/N ratio ranged from16.5 to 23.1 compared to control treatment (24.3).

Table 3. Nitrogen (N) phosphorus (P), potassium(K), whole phenol and chlorophyll contents in leaves of tomato infected with *Meloidogyne incognita* treated with *Tagetes erecta* or *Capsicum annuum* or *Trigonella foenum- graecum*.

Treatments	*Chemical components											
	N%	P %.	K%	C%	C / N	O.M %	Chlorophyll content mg /g				Phenol mg/100g	Inc.%
							Chlo. a	Chlo.b	a+b	Red. %		
Capsicum annuum	1.5j	0.34l	1.8k	34.4m	22.9	59.1m	0.53 l	0.37 m	0.91 m	14.1	564.4 d	17.6
Tagetes erecta	1.5j	0.35k	1.8k	34.7l	23.1	59.7l	0.55 j	0.39 j	0.95 k	14.9	572.1 c	19.2
Trigonella foenum -graecum	1.6i	0.37i	1.9j	35.0k	21.8	60.2k	0.54 k	0.38 l	0.93 l	16.6	579.8 b	20.8
½ (T. foenum -graecum +C. annuum)	1.7h	0.36j	2.0i	35.2j	20.7	60.5j	0.56 i	0.40 i	0.96 i	13.2	541.5 g	12.9
½ (T. erecta +C. annuum)	1.7h	0.37i	2.1h	35.5i	20.8	61.1i	0.57 h	0.41 h	0.98 h	11.8	549.6 f	14.5
½(T. foenum -graecum + T. erecta)	1.8g	0.38h	2.2g	35.9h	19.9	61.7h	0.58 g	0.42 g	1.00 g	10.1	557.2 e	16.1
⅓ (T. erecta+ T. foenum -graecum + Ox)	2.0e	0.41f	2.5d	36.9e	18.4	63.4e	0.61 c	0.46 c	1.07 c	3.6	515.3 j	7.4
⅓ (C. annuum + T. foenum- graecum+ Ox)	2.1d	0.42d	2.6c	37.2d	17.7	63.9d	0.60 d	0.45 d	1.05 d	5.2	506.1 k	5.5
⅓ (C. annuum + T. erecta + Ox)	2.2c	0.43c	2.6c	37.6c	17.0	64.6c	0.62 b	0.47 b	1.09 b	1.8	523.8 i	9.2
⅓(C. annuum + T. foenum graecum + T. erecta)	1.9f	0.40	2.4e	36.5f	19.2	62.8f	0.59 e	0.44 e	1.04 e	6.9	495.9 l	3.4
¼(C. annuum +T. foenum- graecum + T. erecta +Ox	2.3b	0.44b	2.8b	38.0b	16.5	65.3b	0.59 f	0.37 n	0.96 j	18.1	593.4 a	23.7
Oxamyl (Ox)	1.8g	0.39g	2.3f	36.2g	20.1	62.3g	0.58 f	0.43 f	1.02 f	8.6	532.7 h	11.0
Nematode only (N)	1.4k	0.33m	1.7l	34.1n	24.3	58.6n	0.63 a	0.48 a	1.11 a	--	479.8 n	--
Healthy plant	2.4a	0.45a	2.8a	38.3a	15.9	65.9a	0.54 k	0.39 k	0.93 l	16.3	487.2 m	1.5
LSD	0.006	0.004	0.008	0.009	---	0.014	0.005	0.002	0.007		0.204	

N = 2000 (J2s) of *M. incognita* Ox=Oxamyl * Each figure is the mean of four replicates O.M.= Organic matter *Means in each column followed by the same letter(s) did not differ at $p<0.05$ according to Duncan's multiple-range test.

Discussion

The use of dried leaf powders of *T. erecta*, *C. annuum* and *T. foenum -graecum* alone or mixed plays an imperative role in reducing the root-knot nematode *M. incognita* on tomato plants. *T. foenum- graecum* dried leaf powder achieved the highest reduction in nematode parameters. The anti-nematode effect of the tested elements is probably due to their high content of certain oxygenated compounds that have lipophilic properties that enable them to solubilize the cytoplasmic membrane of nematode cells and their functional groups that interfere with the enzyme protein structure (Knobloch et al., 1989). The mechanisms of action of *T. foenum- graecum* leaves may be due to their chemical composition, as they are considered the richest plants in vitamins A, B, C, D, E, and K (Visuvanathan et al, 2022).

The combined effect of dried leaf powders of certain ornanemtal plants showed nematicidal activity against root-knot nematode, *M. incognita* infecting tomato and hence enhanced plant parameters (Khairy et al., 2022). In the present study, quadruple application including dried leaf powders of *T. erecta, C. annuum* and *T. foenum -graecum* plus oxamyl showed a high synergistic effect on reducing nematode population, galls and egg masses numbers as well as improving tomato plant growth.

Moreover, the significant increment values of N, P, and K in tomato leaves has been associated with the introduction of tested materials with oxamyl against *M. incognita*, a situation stated by a number of researchers (El-Sherif and Ismail 2009; Khairy, 2016, 2020; khairy et al, 2022). El-Sherif and Ismail (2009) reported that treatment with ½ (Bt + Ox) topped Bt (*Bacillus thuuringiensis* or oxamyl alone and led to a remarkable increase in N, P and K values in soybean plants diseased with *M. incognita*.

Meanwhile, the same trend happened in the case of total phenolic content in tomato plants infected with *M. incognita* and was in accordance with that reported by Shalaby et al. (2021) regarding powdered seeds treatments of six plant species *Brassica rapa*, *Eruca sativa*, *Juniperus communis*, *Lepidium sativum*, *Raphanus sativus*, *Sinapis alba* that led to significant increment in total phenols in pepper plants infected with *M. incognita*. Increased levels of total phenolics may serve as defensive compounds against pathogens (Kosuge, 1969).

However, there were negative correlations between single and simultaneous applications of the tested components with regard to the decrease of total chlorophyll content compared to nematode only, a situation consistent with that reported by El-Sherif and Ismail (2009)& Shalaby et al. (2021).

Regarding C/N ratio, Miller and Donahue (1990) stated that organic wastes with a C/N ratio of 20:1 or narrow contain enough nitrogen to supply decomposing microorganisms as well as to release them for plant use.

The nematicidal efficacy of the experienced materials as biofertilizers in the integrated management of *M. incognita* on tomato plants with oxamyl can vary from one component to another. These differences can be credited to differences in the chemical nature and compound current in these materials and the application method used. The safety of these materials and their low cost are their advantages.

CONCLUSION

This study showed that the three dried leaf powders tested with nematicide combined as quadruple application achieved significant reductions in nematode reproduction parameters. Such techniques can be used as nematicidal alternatives to control *M.incognita* .

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تقييم فعالية ثلاثة مساحيق أوراق نباتية جافة علي تكاثر نيماتودا تعقد الجذور *Meloidogyne incognita* تحت ظروف الصوبة الزراعية

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الملخص

النيماتودا النباتية التطفل هي الأكثر شيوعًا وتدميرًا بين الامراض النباتية في العقدين الأخيرين، كما انها واحدة من أصعب الأمراض النباتية التي يصعب مكافحتها والسيطرة عليها. تم إجراء تجربة تحت ظروف الصوبة الزراعية لتقييم تأثير ثلاثة مساحيق أوراق نباتية جافة لكل من الحلبة والقطيفة والفلفل الحار سواء كمعاملات منفردة أو مدمجة معًا أو مع المبيد النيماتودي (الأوكساميل) كمعاملات مزدوجة أو ثلاثية أو رباعية على تكاثر نيماتودا تعقد الجذور *M. incognita*، تحت ظروف الصوبة الزراعية. حيث أشارت النتائج إلى أن :جميع المعاملات المختبرة حسنت معايير النمو النباتي وخفضت مقاييس النيماتودا المختبرة بدرجات متفاوتة. تفوق مسحوق اوراق نبات الحلبة على المعاملات امنفردة الأخرى التي تم اختبارها في قيم الزيادة لمعايير نمو النبات الكلي. أظهرت المعامله الرباعية لهذه المواد تأثيرًا ملحوظا في تقليل التعداد النهائي للنيماتودا وكذا عدد العقد النيماتودية وكتل البيض بقيم 91.5 و 92.5 و 94.8٪ على التوالي. أظهر محتوى الكلوروفيل للمعاملات الفردية قيم نسب خفض عالية تراوحت ما بين 14.1 إلى 16.6% بينما حققت المعاملة الرباعية أعلى نسبة خفض (18.1%) مقارنة بمعاملة النيماتودا فقط.اعطت جميع المعاملات المختبرة زيادة معنوية في تركيز N و P و K والفينول مقارنة بالنيماتودا وحدها حيث اعطت المعاملة الفردية *T. foenum-graecum* أفضل زيادة في تركيزات N و P و K والفينول الكامل (1.6، 0.3، 1.9 و 20.8٪)، في حين حققت المعاملة الرباعية أعلى نسبة زيادة (2.3، 0.44، 2.79 و 93.4٪) علي التوالي.