

Assessing the potential of some Egyptian plants as soil amendments in *Meloidogyne incognita* management on tomato

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ABSTRACT

In a pot experiment, dried plant materials of *Brassica oleracea*, *Bougainvillea spectabilis*, *Emex spinosa* and *Erythrina humina* were mixed with soil at the rate of 5 and 10 g/kg soil and compared their nematicidal potential with oxamyl, against the root-knot nematode, *Meloidogyne incognita* infecting tomato plants under greenhouse conditions. In addition, their effects on the growth of tomato plants were also assessed. The results showed that all the amendments exhibited varying degree of reduction compared to control. Moreover, *Erythrina humenea* recorded the highest reductions in galls/ root system (96.77%), egg masses/ root system (97.99%), eggs/ mass (77.11%) and soil populations/250g soil (93.60%). Except *E. spinosa*, employing high rate of the tested dried plants gave higher activity in suppressing the nematode parameters than the low rate. Besides highly nemato-toxic potential, *B. oleracea*, *B. spectabilisor*, *E. spinosa* showed phytotoxic effects on tomato when used at the high rate. These dried plant materials at low rate show promising nematicidal activity and may offer possibilities as non-chemical alternatives for the management of *M. incognita* on tomato.

Keywords: Organic amendment; Plant materials; Nematicidal potential; root-knot-nematodes

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INTRODUCTION

Plant-parasitic nematodes have been implicated as a major constraint to tomato production (Luc *et al.*, 2005). In general, the most widespread nematode species are the root-knot nematodes (*Meloidogyne spp.*). Yield loss of about 20.6% in tomatoes has been attributed to *Meloidogyne* species (Luc *et al.*, 2005). Among the most widely distributed pathogenic species of root knot nematodes, *M. incognita* ranks first, incurring huge qualitative and quantitative losses to crops, especially in subtropical and tropical regions of the globe. Such enormous losses incurred by *M. incognita* necessitate the implementation of management strategies against this pest.

Among various nematode management practices employed, chemical control has been

most sought till recent years because of its immediate results against these pathogens (Sikora and Fernández, 2005). However, increasing awareness regarding their harmful effects on environment, human health and non-target organisms (Rich *et al.*, 2004), has forced the researchers to look for the safer and ecofriendly alternative practices of nematode management (Manju and Sankari Meena, 2015).

Among these practices, the use of botanicals is a very attractive alternative because they degrade to nontoxic products, less harmful to non-target organisms and on environment friendly (Tariq *et al.*, 2018). There are good number of plants having nematicidal substances in their leaves, fruits, seeds, bulbs and even roots (Radwan *et al.*, 2007; Wiratno *et al.*, 2009; Moosavi 2012; Radwan *et al.*,

2012). Some of them give the benefit of green manure along with nematode control. In the past, potential of some of these plants has been exploited and many of them proved effective for use in nematode management programs.

Soil amendments with organic materials not only safe but also improve soil structure and fertility (Scotti *et al.*, 2015). These materials of plant origin have been reported to suppress plant-parasitic nematode populations directly and enhance growth of microbial antagonists of nematodes (Zasada *et al.*, 2002; Oka, 2010). Therefore, the objective of the present study aims to evaluate the potential of dried materials of some Egyptian plant species as soil amendments for the management of *M. incognita* infecting tomato plants.

MATERIALS AND METHODS

Collection and preparation of plant materials

Four plant species were collected from different locations at Alexandria Governorate. The plant species were cabbage (*Brassica oleracea* L.), great bougainvillea (*Bougainvillea spectabilis* L.), prickly dock (*Emex spinosa* L.) and dwarf coral (*Erythrina humenea* L.). Leaves of all plant species except the ariel part of *E. spinosa* were air dried under laboratory conditions for about two weeks. Plant materials were chopped to small pieces and left to complete drying process for a few days. The drying of plant materials was completed in an oven at 40 °C for 72 hrs. Consequently, dried plant materials were grind, sieved and stored in plastic bags until use. The elemental analysis and C/N ratio of the tested dried plant species are presented in Table (1).

Plant scientific name	Elements (%)				C/N ratio
	N	P	K	C	
<i>B. oleracea</i>	0.27	0.20	2.0	20.5	76:1
<i>B. spectabilis</i>	1.32	0.13	2.5	21.6	16:1
<i>E. spinosa</i>	1.58	0.18	1.8	22.1	14:1
<i>E. humina</i>	1.49	1.37	1.5	22.3	15:1

Root-Knot Nematode inoculum

Root-knot nematode inoculum used in the present study was obtained from infected roots of tomato plants (*Solanum lycopersicum* cv. Golden Stone) grown in sterilized soil. Galled roots were washed from the adhering soil

practices by running water and the roots were cut into small pieces, then shaken for 3 minutes in 0.5 % sodium hypochlorite (NaOCl) solution to dissolve the gelatinous matrix and to get free nematode eggs from the mass matrices (Hussey and Barker, 1973). The suspension was passed through a 200-mesh sieve nested upon a 400-mesh sieve. The eggs on the 400-mesh sieve were washed to free the residu of NaOCl via a slow stream of tap water before inoculation. The perineal patterns method (Taylor and Nelscher, 1974) was used for the identification of the species for root-knot nematode inoculum and the inoculum species was identified as *Meloidogyne incognita*.

Pot experiment

The nematicidal performance of dried four plant materials namely; *B. oleracea*, *B. spectabilis*, *E. spinosa* and *E. humenea* as soil amendments against *M. incognita* on tomatoes was investigated under greenhouse conditions. Each dried plant material was incorporated into loamy sand soil at the rate of 5 and 10 g/kg soil and left for one week before transplanting to ensure the proper decomposition of the additives (Alam *et al.*, 1980). The nematicide oxamyl (24% SL) was used for comparison. Pots with and without nematodes were used for controls. Each treatment was replicated five times and all were arranged in a complete randomized design on a bench under greenhouse conditions. After waiting period, one tomato seedling, *Solanum lycopersicum* L. cv. SHEIFA of 40 days old was transplanted in each pot. The infection was accomplished by 5000 nematode eggs/pot after four days from transplanting time. After 65 days from inoculation time, plants were uprooted and the roots were washed free of soil. The shoot and root lengths, in addition to their dry weights were recorded. In addition, number of galls/root system, number of egg-mass, eggs/egg-mass and number of J2/250 g soil were estimated.

Statistics analysis

Using a computer program CoStat Version: 6.303 (2005), the obtained data were subjected

to the analysis of variance test (ANOVA) as complete randomized design (CRD) and means were compared for significance by LSD method at the 5% level of probability.

RESULT AND DISCUSSION

Dried plant materials against *M. incognita* infecting tomato plants

Data illustrated in Table 2 showed that all treatments at the two applied rates (5 and 10 g/kg) were effective in reducing gall numbers compared with untreated check. The greatest mean reduction percentages in tomato galls were recorded in soil amended with oxamyl, *E. humenea* and *B. oleracea* accounted by 98.71, 96.77 and 95.80 %, respectively. These plant materials at both rates did not significantly differ with that of oxamyl. While soil incorporated with *B. spectabilis* and *E. spinosa* gave mean reduction percentages of 91.28 and 90.30 %, respectively.

Moreover, all of the dried plant materials in addition to oxamyl as a standard nematicide have a significant potential in reducing egg masses/root system when compared to untreated check. The superior treatments which minimized egg masses were oxamyl, *E. humenea*, *B. oleracea* and *E. spinosa* with mean reduction percentages of 100, 97.99, 97.13 and 94.26%, consequently, without significant differences between them. The treatment of *B. spectabilis* recorded the less mean reduction percentage of 90.23%.

Oxamyl and *E. humenea* decreased the number of eggs/egg mass in plants by 100 and 77.11%, consecutively [A1]. These mentioned treatments significantly differ from untreated check. The treatments of *B. oleracea* and *B. spectabilis* were ranked in between the highest and the lowest treatments, and recorded decrement in eggs/egg mass calculated by 66.41 and 61.54% respectively. The mean reduction percentage of eggs/egg mass caused by *E. spinosa* was 47.69%.

On the other hand, the J2 population in the soil was significantly suppressed with all the applied treatments. Oxamyl and *E. humenea* recorded the greatest mean reduction percentage in J2/250g soil which accounted by 98.85 and 93.61%, respectively. Moreover, *B. spectabilis* and *B. oleracea* achieved mean

reduction percentage in J2 reached 86.81 and 84.23%, consecutively [A1]. The treatment of *E. spinosa* was less efficient with mean reduction of 79.71%.

Except *E. spinosa*, the high rate of *B. oleracea*, *B. spectabilis* and *E. humenea* showed higher nematicidal activity in suppressing the nematode both in the soil and in tomato roots than their low rates. The findings of the present study are in full agreement with those obtained by several authors Radwan *et al.* (2006) reported that soil amended with dried leaves of *E. spinosa* at the rate of 5 and 10 g/kg soil reduced tomato root galls of *M. incognita* by 81.59 and 91.04 and J2 in the soil by 79.59 and 87.19%, respectively. El-Sherbiny and Zen-El-Dein (2012) showed that *B. spectabilis* and *E. humenea* were the superior treatments which reduced galls by 98.23 and 98.82%, egg masses by 98.93 and 99.14 % as well as J2 in the soil by 99.08 and 99.23, respectively. However, Lily *et al.* (2015) reported that the leaf powder of *B. spectabilis* relatively decreased galls of *M. incognita* when applied 15 days before the transplanting. Otherwise, it was reported that cabbage leaf residue (*B. oleracea*) reduced the population density of *M. hapla*, by 54.14 % (Anita, 2012).

In the present study, the incorporation of some dried plant species as soil amendments significantly suppressed *M. incognita* criteria and this may be attributed to the decomposition of plant materials in the infested soil especially before planting releasing certain phytochemical constituents which are toxic to nematodes (Chitwood 2002). Moreover, some mechanisms are involved for the explanation of toxic effect of the tested organic amendments such as the release of ammonia, fatty acids, induce the plant tolerance and create unsuitable atmosphere in the soil for nematode behavior (Thoden *et al.*, 2011; Chindo *et al.*, 2012). In addition, soil amended with organic materials will promote plant growth due to the availability of nutrients during the decomposition of these amendments which

significantly inhibited the nematode population (Amarasinghe, 2011).

Phytochemical constituents released during the decomposition of *B. spectabilis* were cyanogenic glycosides, quinones, saponins, triterpenoids, flavonoids, alkaloids, sterols, tannins, furanoids and phenols (Francisco and Pinotti 2000; Umamaheswari *et al.*, 2008). While *E. humenea* released alkaloids, coumarins, steroids, flavonoids and terpenoids (de Araújo-Júnior *et al.*, 2012), which may be

toxic to parasitic nematodes. Besides, *B. oleracea* is one of the brassicaceous plants which contain many sulfur compounds called as glucosinolates (GLSs) which are broken down in the soil to isothiocyanates and other related compounds. Other phytochemical constituents found in brassicaceous plants such as phenols and ascorbic acids, may compliment the nematicidal activity of GLSs (Zasada and Ferris, 2004; Avato *et al.*, 2013).

Table 2. The suppressive effect of some dried plant materials as soil amendments on the development of root-knot nematode *Meloidogyne incognita* infecting tomato in a pot experiment under greenhouse conditions

Treatments	Rate (g/kg soil)	Galls / root system			Egg masses / root system			Eggs / egg mass			J2 /250g soil		
		Mean	*R (%)	**MR (%)	Mean	R (%)	MR (%)	Mean	R (%)	MR (%)	Mean	R (%)	MR (%)
Control	-	92.80 ^a	-	-	34.80 ^a	-	-	477.56 ^a	-	-	2498.80 ^a	-	-
<i>B. oleracea</i>	5g	5.80 ^{cd}	93.75	95.80	1.80 ^{cd}	94.83	97.13	262.80 ^c	44.97	66.41	510.60 ^c	79.57	84.08
	10g	2.00 ^d	97.84		0.20 ^d	99.43		58.00 ^e	87.85		284.80 ^e	88.60	
<i>E. humenea</i>	5g	4.80 ^{cd}	94.83	96.77	0.80 ^{cd}	97.70	97.99	121.20 ^{ef}	74.62	77.11	210.80 ^f	91.56	93.60
	10g	1.20 ^d	98.71		0.60 ^d	98.28		97.40 ^{fg}	79.60		108.80 ^g	95.65	
<i>B. spectabilis</i>	5g	10.60 ^{bc}	88.58	91.27	5.20 ^b	85.06	90.23	217.60 ^d	54.44	61.53	350.80 ^d	85.96	86.81
	10g	5.60 ^{cd}	93.97		1.60 ^{cd}	95.40		149.80 ^e	68.63		308.60 ^{de}	87.65	
<i>E. spinosa</i>	5g	1.80 ^d	98.06	90.30	0.20 ^d	99.43	94.25	72.00 ^g	84.92	47.69	261.00 ^{ef}	89.55	79.71
	10g	16.20 ^b	82.54		3.80 ^{cd}	89.08		427.60 ^b	10.46		753.20 ^b	69.86	
Oxamyl	0.05 ml	1.20 ^d	98.71	98.71	0.00 ^d	100.00	100.00	0.00 ^h	100.00	100.00	28.80 ^h	98.85	98.85
LSD _{0.05}		8.45	---	---	3.04	---	---	45.12	---	---	63.48	--	---

Means in each column followed by the same letter(s) are not significantly different according to LSD ($p = 0.05$).

*R (%) = Reduction percentage, **MR (%) = The mean of reduction percentages.

Accordingly, the C/N ratio of the dried plant materials in the present study is important. It was noticed from the literature that the nematicidal activity of dried plant parts generally depend on the C:N ratio, amount of the amendment used and time for the decomposition in soil (El-Sherbiny and Awd Allah 2014). Moreover, organic materials with C:N ratio less than 20:1 have higher decomposition rate in soil and nematicidal activity (Stirling, 1991; Ritzinger and McSorley, 1998; Mashela, 2002) and enhanced the number of microorganisms in the soil that antagonistic to phytonematodes (Renco, 2013).

Dried plant materials on tomato growth

The effects of the tested dried plant materials with two rates on tomato plant growth are presented in Table 3. Data revealed that, in control treatment, *M. incognita* reduced plant

growth criteria compared to nematode-free plants. However, the length of shoot system of plants treated with *B. spectabilis* and oxamyl was increased by 37.00 and 22.28% over the untreated check, respectively. The remaining treatments, *E. humenea*, *E. spinosa* and *B. oleracea* recorded relative mean increasing percentages calculated by 11.26, 8.79 and 4.46%, respectively. However, the higher rates of *B. oleracea* and *E. spinosa* showed phytotoxic effect resulting from the reduction of shoot length by 10.40 and 9.16%, respectively. For the dry weight of shoot system, the highest increase over control was observed in plants treated with *B. spectabilis* without any significant differences between the high and low rates. Moreover, *E. humenea*, *B. oleracea* and *E. spinosa* showed mean percent increases of 27.01, 20.93 and 20.74%, respectively. On the other hand, oxamyl decreased dry weight of the shoot system. The

length of root system was also recorded and the superior treatments were *E. humenea*, *B. spectabilis* and *B. oleracea* which achieved mean increases percentages of 24.00, 16.22 and 10.44%, respectively. While the remaining treatments i.e. oxamyl and *E. spinosa* exhibited relative increase in the mean percentage as calculated by 6.67 and 1.56%, respectively. The higher rates of *E. spinosa* reduced the root length and this may be attributed to the phytotoxic effect. Oxamyl significantly increased the dry weight of root system with an increased percentage of 46.02%, over the untreated check. Meanwhile, plants grown in soil amended with all of the tested dry plant materials at the two rates gave an increase in the dry weight of root system except - *B. oleracea* at the low rate as well as *B. spectabilis* at the high rate, which decreased it by 3.89 and 3.36%, respectively.

Earlier reports confirmed that different dried plant parts when used as soil amendments against *Meloidogyne* spp. improved plant growth such as *B. oleracea* (Al-Abed *et al.*, 2011; Anita 2012) and *B. spectabilis* and *E. humenea* (El-Sherbiny and Zen-El-Dein 2012). In contrast, some other dried plant leaves amended soil affected the plant growth parameters and this may be attributed to the

phytotoxic effect in accordance with those results reported by Radwan *et al.* (2006) who mentioned that *E. spinosa* at the rate of 5 and 10 g/kg soil significantly decreased growth indices of tomato over control particularly in the shoot system.

Application of organic matter to the soil is known to have beneficial effects on soil nutrients, soil physical conditions, soil biological activity and crop performance. Therefore, the growth improvement of tomatoes following amendment with the dried plant materials can be attributed partly to nematode control and partly to an increase in soil nutrients. In turn, this may have helped the plant to better tolerate toward nematode attack (Rodriguez-Kabana *et al.*, 1987; Akhtar and Alam, 1993).

In the present study, therefore, the use of dried materials of some plant species show promising nematicidal activity and offer possibilities as non-chemical alternatives for the management of *M. incognita* on tomato. Moreover, the dried plant materials which exhibited high activity as soil amendments may be subjected to further field investigation through integrated nematode management strategy.

Table 3. The influence of some dried plant materials at two rates as soil amendments on the growth of tomato plant infected with *M. incognita*

Treatments	Rate (g / kg soil)	Shoot system						Root system					
		Length (cm)			Dry weight (g)			Length (cm)			Dry weight (g)		
		Mean	Increase (%)	*MI (%)	Mean	Increase (%)	MI (%)	Mean	Increase (%)	MI (%)	Mean	Increase (%)	MI (%)
Untreated check	-	40.40 ^{de}	-	-	2.04 ^c	-	-	22.50 ^{bc}	-	-	1.13 ^c	-	-
Uninoculated plants	-	52.50 ^{ab}	29.95	29.95	2.79 ^{ab}	36.86	36.86	24.00 ^{bc}	6.67	6.67	1.46 ^{ab}	29.38	29.38
<i>Brassica oleracea</i>	5g	48.20 ^{bc}	19.31	4.46	2.56 ^{abc}	25.69	20.93	23.80 ^{bc}	5.78	10.44	1.09 ^c	-3.89	4.60
	10g	36.20 ^e	-10.40		2.37 ^{bc}	16.18		25.90 ^{abc}	15.11		1.28 ^{bc}	13.10	
<i>Erythrina humenea</i>	5g	47.10 ^{bcd}	16.58	11.26	2.60 ^{abc}	27.35	27.01	26.50 ^{abc}	17.78	24.00	1.27 ^{bc}	12.57	12.74
	10g	42.80 ^{sde}	5.94		2.58 ^{abc}	26.67		29.30 ^a	30.22		1.28 ^{bc}	12.92	
<i>Bougainvillea spectabilis</i>	5g	52.90 ^{ab}	30.94	37.00	2.60 ^{abc}	27.25	40.00	26.70 ^{ab}	18.67	16.22	1.25 ^{bc}	10.27	3.45
	10g	57.80 ^a	43.07		3.12 ^a	52.75		25.60 ^{abc}	13.78		1.09 ^c	-3.36	
<i>Emex spinosa</i>	5g	51.20 ^{ab}	26.73	8.79	2.64 ^{abc}	29.22	20.74	24.30 ^{abc}	8.00	1.56	1.22 ^{bc}	8.14	9.82
	10g	36.70 ^e	-9.16		2.29 ^{bc}	12.25		21.40 ^c	-4.89		1.26 ^{bc}	11.50	
Oxamyl	0.05 ml	49.40 ^{bc}	22.28	22.28	2.01 ^c	-1.47	-1.47	24.00 ^{bc}	6.67	6.67	1.65 ^a	46.02	46.02
L.S.D _{0.05}		7.46	---		0.63	---		5.19	---		0.24	---	

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