Pol. J. Environ. Stud. Vol. 31, No. 1 (2022), 307-314
DOI: *10.15244/pjoes/138178* ONLINE PUBLICATION DATE: 2021-10-19

Original Research

Repellent and Nematostatic Behaviour of Botanical Extracts Against Root-Knot Nematode *Meloidogyne incognita* Attacking *Solanum melongena* L.

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Received: 15 August 2020
Accepted: 24 May 2021

Abstract

The current experiment was performed to determine the nematicidal behaviour of aqueous extract of various weed plants *viz., Parthenium hysterophorus, Cymbopogon citratus, Eichhornia crassipes, Monstera deliciosa* and *Tinospora cardifolia* against hatching, mortality and penetration rate of *Meloidogyne incognita* under *in vitro* condition. The eggs and second stage juveniles were exposed to various concentrations (250, 500, 1000, 1500, 2000 and 2500 µg/ml) for 5 days and 12, 24 and 48 h respectively. During the experiment, all plant extracts displayed nematicidal potential. Comparison of LC_{50} values of different plant extracts showed that *P. hysterophorus* was found to be most effective with LC_{50} 664.9 µg/ml, while *T. cardifolia* was less effective at 48h of LC_{50} 1419.0 µg/ml. Aqueous extracts of *P. hysterophorus* at 2500 µg/ml was highly effective against hatching and mortality after 5 days and 72h exposure period respectively. Whereas *T. cardifolia* was found least effective. The macerated leaves of *P. hysterophorus* applied at 0.3 g/kg sand showed the lowest penetration of *M. incognita* in brinjal roots while *T. cardifolia* displayed highest after 3 and 5 days' post inoculation. This study suggests that aqueous extract of the selected plants having nematistatic and nematicidal properties that can be used for the management of *M. incognita* in an eco-friendly manner and sustainable agriculture.

Keywords: aqueous extract, egg hatching, mortality, LC_{50}, *Meloidogyne incognita*, penetration

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Introduction

Vegetables are an important component of agricultural and food security due to their healthy, nutritional richness, short duration, high yield and economic viability. India with the production of 146.55 million tones is the second largest producer of vegetables contributing 14% of world's vegetable production. India has an area of 8.5 million hectares (15% of the world) under vegetable cultivation [1]. Eggplant (*Solanum melongena* L.) is a member of Family Solanaceae. India ranked second with 27% of the world total eggplant production. Nutritionally, it is an important source of phosphorus, calcium, iron and vitamin B. The roots of eggplant are a good source of medicinal value and act as anti-asthmatic and leaves are also used in asthma, bronchitis and cholera. Plant-parasitic nematodes are usually considered as hidden enemies which cause losses up to 80% and have been associated throughout with the vegetables in the severely infested fields [2-3]. Among the plant-parasitic nematodes, the root-knot nematode is a specific pathogen to infect the roots of eggplant. Their management is a difficult task due to wide host range and high reproducibility, thousands of eggs can be produced by a single female [4]. The primary symptoms of nematode infestation are the formation of galls over the roots which results in retarded growth, reduced nutrients quantity and water absorption which cause wilting in plants [5]. *M. incognita* is a major damaging pest affects quantity and quality of the many annual and perennial crops, causing an estimated loss of $100 billion per year worldwide [6]. The nematode, *M. incognita* penetrates the root of brinjal and forms the giant cells, as a result of which the root swell up called galls. The infection starts from the egg hatched second stage juveniles (J_2) in the soil and then juveniles penetrate behind root cap region of roots and migrate intercellularly passing through the cortical tissue up to the vascular region and then become sedentary or stabilized.

The chemical nematicides are one of the potent and effective means of nematode control, but they impose hazardous effects on human beings and environment. Also, they are comparatively costly and unaffordable to the small-scale growers [7]. Moreover, the use of synthetic chemicals pesticides has also been banned due to their carcinogenic nature, toxic residues, creates a hormonal imbalance, spermatotoxicity and prolonged decaying period [8]. The grower's attention is diverting towards developing the biopesticides that are pest specific, non-toxic, cost-effective and ecologically safe [9]. Therefore, this is the need of the hour to develop alternative nematode management methods, which are as effective as synthetic pesticides, safer to farmers, consumers, and the environment and relatively affordable [10]. Nowadays many farmers are facing the problem of seedling failure on the field due to nematode attack, so they need to develop naturally derived nematicide, which is less toxic to human being, animals and environment but as effective against nematodes of various crops as synthetic ones. A large number of plants/plant parts have been screened for their nematicidal activities [11]. Plant extract is a very useful and environment-friendly strategy to manage the root-knot nematode. The toxic effect of aqueous leaf extract of *Achyranthes aspera* and *Solanum xanthocarpum* displayed 100% inhibition in egg hatching and mortality of *M. incognita* juveniles [12]. The nematicidal potential was directly proportional to the concentration of extract, higher the concentration, greater is the nemato-toxic potential and vice-versa. The plants exhibit nematicidal properties due to the presence of compounds such as isothiocyanates, thiophenics, glucosides, alkaloids, phenolics, tannins and fatty acids [13]. Increasing social awareness about the health and ecological impacts of some chemical pesticides has moved on a search for alternative strategies for control of pests [14]. Pramanik et al. [15] studied that the toxic compound release during decomposition of organic matters by the microorganisms is the major mechanism for solubilization of insoluble P and K, which subsequently results in an increase in P and K contents in vermicompost.

The various sources of naturally occurring compounds suppressive to *Meloidogyne* spp. have been recognized which includes a glycoside (asparagusic acid) obtained from *Asparagus officinalis* [16], two recently identified nematicidal compounds such as nonacosane-10-ol and 23a-homostigmast-5-en-3b-olextracted from the roots of *Fumaria parviflora* Lam. [17]. Plant extract is a best alternative to control nematode infestation, according to Chałanska et al. [18] managed foliar nematode *Aphelenchoides ritzemabosi* on *Anemone hupehensis* using extract of plant and pesticides. The exploitation of organic amendments, plant extracts and biopesticidesare gaining foremost concern because of being safe, cost effective and environment-friendly approaches [19-20, 12]. The nematicidal efficacy of *Argemone mexicana* and *Achyranthes aspera* leaves against nematodes may be credited to the presence of the toxic alkaloids in them [21]. During the past decade, research of nematode management was mainly concerned to find out the tactics to inhibit the egg hatching [22], increased mortality of juveniles [23]. Aqueous extracts of *Zinnia peruviana* and *Wedelia* species displayed inhibition in egg hatching of *M. incognita* by 92.72% and 97.48% respectively, when compared to control [24]. Some earthworm is beneficial for the growth of plant such as *Lumbricus rubellus* is feasible in bioconverting vegetable waste spiked with agro-industrial waste into vermicompost, and the product possesses agronomic potential as well as environmentally sounding in contrast to synthesized chemical fertilizer [25].

The implementation of botanical extracts either induces the resistance in plants against the nematode attack or directly activates the plant defense system

[26]. However, Amadioha [27] reported the endless list of plants and their materials with ovicidal and larvicidal properties. The incorporation of organic material (plant parts and their products) into the soil suppresses the population of *M. incognita* and cause enhancement in yield of tomato [28-29]. The aim of this study was to determine the inhibition in egg hatching and mortality of *M. incognita* J2 *in vitro*, penetration rate and subsequent development of root-knot nematode, *M. incognita* by using the macerated leaves and aqueous extracts of different weed plants.

Materials and Methods

Culture for Nematode Inoculum

The roots of eggplant infected with root-knot nematode were collected from an agricultural field near the village mehrawal, Aligarh. The District Aligarh in the state of Uttar Pradesh, India is located at the geographical coordinates 27. 88° N and 78.08° E. The infected roots were washed 2-3 times in the basket filled with water to detect the presence of eggmasses. Eggmasses were handpicked using sterilized forceps from heavily infected roots and washed in Double Distilled Water (DDW), then placed in 15 mesh sieves (8 cm in diameter) containing crossed layer of tissue paper and then placed in Petri dishes having water just deep enough to contact the eggmasses which can help in juvenile hatching that can be used in experiment.

Preparation of Extract

Leaves of five different weed plants species *viz., P. hysterophorus* (Family-Asteraceae), *C. citratus* (Family-Poaceae), *E. crassipes* (Family-Pontederiaceae), *M. deliciosa* (Family-Araceae) and *T. cardifolia* (Family-Menisperamaceae) were collected from Aligarh Muslim University campus, near Allama Iqbal Hall, thoroughly washed and oven dried at 58°C±2°C for 48 h. The dried leaves were converted into powder with the help of a grinder. A stock solution of 2500 µg/ml (2.5 g/L) was prepared in distilled water with 1% Triton X-100 as an emulsifier. Two and half a gram powder of each plant leaves were taken and dissolved in 1000ml water. Further dilutions such as 250, 500, 1000, 1500 and 2000 µg/ml were prepared by adding the requisite amount of distilled water.

Hatching Test

For hatching experiment, five healthy eggmasses of *M. incognita* were picked from the infected eggplant root. Then the eggmasses were transferred into the 40 mm Petri dishes containing different concentrations of extracts like 250, 500, 1000, 1500, 2000 and 2500 µg/ml. Each treatment was replicated three times. The Petri dishes were incubated at 28°C and the total number of hatched juveniles was counted after five days of treatment and also the percent inhibition over double distilled water was calculated. Pure double distilled water served as control.

Mortality Test

For mortality test, 100 freshly hatched second stage juveniles of *M. incognita* were transferred into the 40 mm Petri dishes having different concentrations of the extracts such as 250, 500, 1000, 1500, 2000 and 2500 µg/ml. Each treatment was replicated thrice. The Petri dishes were incubated at 28°C and mortality was counted after 12, 24 and 48 h. Double distilled water served as control. If nematodes appear in a rounded or coiled shape moving in the Petri dishes then they are considered as alive and if they did not show any movement and their body shape looks straight then considered them as dead.

Penetration Test

A disposable teacup of 7 cm was filled with the washed river sand (50g) mixed with the macerated above mentioned fresh plant leaves except *P. hysterophorus* at the doses of 0.1, 0.2 and 0.3 mg/kg. Filled disposable teacup left for two weeks for proper decomposition of maceretaed leaves. After decomposition, three weeks old seedlings of brinjal were transplanted and 100 freshly hatched second stage juveniles of *M. incognita* were inoculated into each cup. For observation, plants were uprooted after 3 and 5 days. After uprooting, the plant roots were gently washed with tap water and cut into approx. 2 mm pieces followed by staining with acid fuchsin-lactophenol and then extra stain was cleared with lactophenol. After staining, roots were placed on a glass slide and observed under a stereomicroscope for the purpose of counting the penetrated juveniles while the second observation of this experiment was to count the remaining population of nematode in the sand. Extraction of nematodes from sand was done by Bearmann funnel method and then their population was counted.

Data Analysis

The percent inhibition in juvenile hatching and the percent mortality were calculated after exposure period(s) for each plant extract by Abbott equation [30]. The 50% lethal concentrations (LC_{50}), their 95% confidence limits (CL), regression equation and coefficient of determination (R^2) were computed by Probit analysis according to Finney [31] and significant difference between LC_{50} values was estimated based on 95% CL overlapping.

Results and Discussion

The nematicidal effect of aqueous extract of the tested plants on hatching of *M. incognita* J2 is presented in Table 1. All treatments were effective against *M. incognita*. However, maximum inhibition in hatching of *M. incognita* J2 showed by the *P. hysterophorus* (45, 65.25, 69, 81, 97 and 100%) and minimum was observed in *T. cardifolia* (29.25, 47.5, 54.5, 67.75, 82.75 and 97.75%) at the concentrations of 250, 500, 1000, 1500, 2000 and 2500 µg/ml, respectively, after 5 days of exposure.

Results presented in Table 2 revealed that highest mortality percentages of J2 was found using *P. hysterophorus* (26, 36, 42, 47, 58 and 80), (29, 39, 47, 51, 67 and 86) and (33, 45, 51, 56, 75 and 91) as well as the least was observed by *T. cardifolia* (15, 23, 28, 30, 37, 64), (17, 28, 33, 34, 33, 69) and (27, 30, 39, 39, 57, 72) at the concentrations of 250, 500, 1000, 1500, 2000 and 2500 µg/ml after 12, 24 and 48 h of exposure period, respectively. On the other hand, aqueous extracts of *C. citratus, E. crassipes*, and *M. deliciosa* leaves showed less mortality after 48 h of exposure as compared to *P. hysterophorus*.

Based on the LC_{50} values (Table 3), the aqueous extracts of the tested plants showed nematostatic and nematicidal effect against *M. incognita* J2. The aqueous extract of *P. hysterophorus* was highly toxic to J2 mortality with LC_{50} values of 1098.8, 853.4 and 664.9 µg/ml after 12, 24 and 48 h of exposure periods, respectively. While the aqueous extract of *T. cardifolia* was least toxic against J2 with the corresponding LC_{50} values of 2686.4, 2418.8 and 1419.0 µg/ml. On the other hand, the LC_{50} values of aqueous extract of *C. citratus* were 1390.3, 1063.3, and 769.3 µg/ml, *E. crassipes* were 1736.7, 1349.3 and 950.2 µg/ml and *M. deliciosa* were 2089.7, 1598.5 and 1151.8 µg/ml after 12, 24 and 48 h of exposure periods, consecutively. Generally, the aqueous extract of *P. hysterophorus* was highly toxic against J2 mortality followed by *C. citratus, E. crassipes, M. deliciosa* and *T. cardifolia*.

The impact of aqueous extracts of *P. hysterophorus, C. citratus, E. crassipes, M. deliciosa* and *T. cardifolia* against *M. incognita* juvenile penetration in the brinjal roots is presented in Table (4). At all the tested doses, the minimum penetration of J2 was observed by *P. hysterophorus* followed by *C. citratus, E. crassipes, M. deliciosa* and T. *cardifolia* after 3 and 5 days of inoculation. In general, higher dose of all tested plants prevented the penetration of J2 in the brinjal roots, whereas the lowest dose displayed minimum penetration after 3 and 5 days of inoculation compared with the untreated inoculated control. From the above results, it was found that macerated leaves of some plants *viz*., *P. hysterophorus, C. citratus, E. crassipes, M. deliciosa* and *T. cardifolia* have nematostatic and nematicidal properties and could be used for the management of root-knot nematode, *M. incognita* for the sustainable environment.

The results obtained from this study revealed that different concentrations of aqueous extracts of five plant leaves *viz*., *P. hysterophorus*, *C. citratus*, *E. crassipes*, *M. deliciosa* and *T. cardifolia* showed a nematicidal efficacy against root-knot nematode, *M. incognita in vitro*. The purpose of this study was to illustrate the use of plant extracts in managing the root-knot nematodes instead of using chemical pesticides to decrease the release of harmful environmental pollutants. Results of our experiments indicated that the selected plant extracts of *P. hysterophorus* (LC_{50} = 853.4 µg/ml) and *C. citratus* (LC_{50} = 1063.3 µg/ml) exhibit highest nematicidal activity on the J2 mortality of *M. incognita*

Table. 1. Effect of aqueous extracts of fresh chopped leaves of different plant species on the juvenile hatching of *Meloidogyne incognita in vitro* after 5 days.

Treatments	Number of juvenile hatched at given different concentration in µg/ml									
	250	500	1000	1500	2000	2500	DW	CD	CV	F
Parthenium hysterophorus	220±9.45 (45)	139± 8.50 (65.25)	124±7.21 (69)	76±5.85 (81)	12±3.05 (97)	0±0 (100)	400±0 (0)	18.56	7.57	518.31
Cymbopogon citratus	236±8.02 (41)	152±9.45 (62)	137± 6.80 (65.75)	90±5.29 (77.5)	25±4.04 (93.75)	0±0 (100)	400±0 (0)	18.09	6.88	533.73
Eichornia crassipes	251±5.29 (37.25)	172±4.61 (57)	155±5.50 (61.25)	100±5.68 (75)	39±4.93 (90.25)	2±0.57 (99.5)	400±0 (0)	13.53	4.78	932.66
Monstera deliciosa	268±5.77 (33)	191±5.13 (52.25)	169±6.08 (57.75)	116±8.08 (71)	56±4.93 (86)	4±1.15 (99)	400±0 (0)	15.85	5.21	661.36
Tinospora cardifolia	283±4.58 (29.25)	210±2.30 (47.5)	182±5.13 (54.5)	129±5.50 (67.75)	69±5.85 (82.75)	9±2.64 (97.75)	400±0 (0)	12.90	3.98	975.93

DW-Distilled water
CD-Critical difference
CV-Coefficient of variation
F- F test
Each value is an average of three replicates±SE
Values for percent inhibition in juvenile hatching over control are given in parenthesis.

Table. 2. *In vitro* impact of aqueous extract of chopped leaves of different plant species on the mortality of *Meloidogyne incognita* juveniles.

Treatments	Exposure periods (h)	Percent mortality of J2 at given different concentration in µg/ml									
		250	500	1000	1500	2000	2500	DW	CD	CV	F
Parthenium hysterophorus	**12**	26±3.12 (26)	36±4.16 (36)	42±6.24 (42)	47±4.61 (47)	58±5.03 (58)	80±8.08 (80)	0±0 (0)	15.47	21.19	24.66
	24	29±11.28 (29)	39±7.28 (39)	47±2.02 (47)	51±4.72 (51)	67±4.72 (67)	86±8.02 (86)	0±0 (0)	19.80	31.78	9.58
	48	33±4.72 (33)	45±4.72 (45)	51±4.35 (51)	56±5.56 (56)	75±4.72 (75)	91±4.72 (91)	0±0 (0)	13.66	15.41	43.17
Cymbopogon citratus	**12**	23±9.33 (23)	33±6.88 (33)	38±1.45 (38)	43±4.16 (43)	52±5.45 (52)	75±0.33 (75)	0±0 (0)	15.6	31.49	9.00
	24	28±5.03 (28)	37±5.85 (37)	43±3.60 (43)	49±5.85 (49)	57±5.50 (57)	79±5.50 (79)	0±0 (0)	14.98	20.25	25.25
	48	35±2.51 (35)	41±5.13 (41)	49±5.85 (49)	51±5.85 (51)	69±5.85 (69)	82±4.35 (82)	0±0 (0)	14.39	17.42	31.05
Eichornia crassipes	**12**	21±3.21 (21)	30±6.11 (30)	36±4.58 (36)	39±5.85 (39)	47±4.72 (47)	70±4.93 (70)	0±0 (0)	14.16	23.07	22.07
	24	25±4.72 (25)	32±5.29 (32)	40±4.16 (40)	43±3.60 (43)	54±4.16 (54)	74±3.05 (74)	0±0 (0)	11.99	17.71	35.10
	48	31±4.72 (31)	37±4.50 (37)	43±3.78 (43)	49±4.93 (49)	66±5.29 (66)	79±4.72 (79)	0±0 (0)	13.28	17.24	34.44
Monstera deliciosa	**12**	18±4.16 (18)	27±1.52 (27)	32±5.29 (32)	33±5.68 (33)	42±5.03 (42)	70±4.58 (70)	0±0 (0)	13.01	23.20	25.76
	24	22±2.51 (22)	29±3.21 (29)	37±4.50 (37)	38±5.29 (38)	49±5.50 (49)	74±5.03 (74)	0±0 (0)	12.71	20.21	30.53
	48	29±3.51 (29)	35±4.04 (35)	42±2.30 (42)	43±3.78 (43)	60±5.29 (60)	76±4.58 (76)	0±0 (0)	11.42	15.86	41.37
Tinospora cardifolia	**12**	15±3.60 (15)	23±3.78 (23)	28±3.05 (28)	30±5.29 (30)	37±3.51 (37)	64±5.03 (64)	0±0 (0)	11.71	23.53	26.89
	24	17±2.88 (17)	28±4.16 (28)	33±4.72 (33)	34±6.11 (34)	33±4.04 (33)	69±4.58 (69)	0±0 (0)	12.82	23.71	24.97
	48	27±4.72 (27)	30±4.61 (30)	39±4.66 (39)	39±4.66 (39)	57±2.51 (57)	72±4.16 (72)	0±0 (0)	12.18	18.60	33.07

DW-Distilled water;
CD-Critical difference;
CV- Coefficient of variation,
F- F test
Each value is an average of three replicates±SE
Values percent mortality in juveniles over control are given in parenthesis.

after 24 h of the exposure periods *in vitro*. Interestingly, both extracts gave LC_{50} values less than *E. crassipes, M. deliciosa* and *T. cardifolia*. The toxicity depends on the exposure period and concentration of extract. The LC_{50} values of *P. hysterophorus* and *C. citratus* have high ability in the J2 mortality of *M. incognita* after 24 h. Our results are corroborating with Ayazpour et al. [32], who showed that water leaf extract of *Allium sativum* was more effective against the citrus nematode, *Tylenchulus semipenetrans* followed by *Capsicum frutescens*, *Datura innoxia* and *Foeniculum vulgare*. The high J2 mortality of 91% was observed in 5000 µg/ml methanolic extract of *Phyllanthus amarus* after 72 h of exposure with LC_{50} value of 2084.49 µg/ml and repression of egg hatching [33]. In our study, all plants showed the suppressive effect of the root-knot nematode, *M. incognita*. Radwan et al. [34] investigated dried ground leaves of *Cynodon dactylon, Datura stramonium, Eichhornia crassipes, Emex spinosus, Ricinus communis* and *Sisymbrium irio* that applied at the rate of 1, 3, 5 and 10 g/kg soil against *M. incognita* and they found that *Sisymbrium irio* was highly effective for nematode and helpful to enhance the growth of tomato. Also, Tariq et al. [35] found that different plant green manure against *M. incognita* reduced the infestation of nematode in terms galling index and eggmasses.

Three days after inoculation, a parasitic relation was established between *M. incognita* J2 and brinjal

Table 3. Toxicity parameters of aqueous extract of chopped leaves of different plant species against juveniles of *Meloidogyne incognita.*

Treatments	Exposure periods (h)	LC_{50} in µg/ml (95% CL)	Regression equation	R^2
Parthenium hysterophorus	**12**	1098.8 (710.4-1699.4)	y = 1.19x + 1.39	0.786
	24	853.4 (572.6-1272.0)	y = 1.35x + 1.07	0.789
	48	664.9 (452.5-977.0)	y = 1.46x + 0.88	0.769
Cymbopogon citratus	**12**	1390.3 (880.5-2195.5)	y = 1.12x + 1.47	0.790
	24	1063.3 (668.2-1692.0)	y = 1.11x + 1.63	0.786
	48	769.3 (480.8-1230.8)	y = 1.13x + 1.74	0.784
Eichhornia crassipes	**12**	1736.7 (1070.2-2818.3)	y = 1.05x + 1.59	0.793
	24	1349.3 (843.4-2158.8)	y = 1.08x + 1.61	0.804
	48	950.2 (604.3-1494.1)	y = 1.14x + 1.59	0.798
Monstera deliciosa	**12**	2089.7 (1305.2-3345.6)	y = 1.08x + 1.39	0.725
	24	1598.5 (1011.0-2527.5)	y = 1.11x + 1.44	0.748
	48	1151.8 (708.2-1873.0)	y = 1.05x + 1.78	0.760
Tinospora cordifolia	**12**	2686.4 (1665.1-4334.1)	y = 1.07x + 1.30	0.755
	24	2418.8 (1444.8-4049.3)	y = 0.99x + 1.62	0.633
	48	1419.0 (868.7-2317.9)	y = 1.03x + 1.75	0.759

LC_{50}- Lethal concentration causing 50% mortality after 12, 24 and 48 h with 95% CL in parenthesis
CL- Confidence limit

roots. All the selected plant species were effective in reducing the penetration of J2 in the host roots either at different doses or after the two times from inoculation. However, the *P. hysterophorus* and *C. citratus* are highest effective at the dose of 0.3 g/kg while *E. crassipes, M. deliciosa* and *T. cardifolia* were less effective. El-Habashy et al. [36] studied 17 phytochemicals against *M. javanica* under *in vitro* conditions, and showed that three phytochemicals *viz*., α-pinene, α-terpinene and nerolidol were highly effective in reducing egg hatching. Laquale et al. [37] investigated the *in vitro* activity of plant extracts from *Echinacea angustifolia, E. pallida* and *E. purpurea* against juveniles and eggs of *M. incognita* and found that *E. angustifolia* was highly effective against the nematodes. Some selected plant which is responsible to release phytochemicals and indoor CO_2 concentration [38]. From the above experiment, it may be concluded that the aqueous extract of selected plants *viz*., *P. hysterophorus*, *C. citratus*, *E. crassipes*, *M. deliciosa* and *T. cardifolia* having nematistatic as well as nematicidal properties that can be used for the management of *M. incognita* in an eco-friendly manner and sustainable environment.

Conclusion

Aqueous extracts of all the plants were found lethal to second stage juveniles of *M. incognita*. The rate of mortality was directly proportionate to the concentration of extracts. All plant extracts showed inhibitory effect on egg hatching of *M. incognita*. The rate of hatching was inversely proportional to the concentration of extracts and exposure period, as it decreased with increase in concentration. Metabolites produced by plant parts are a potential source of new nematicidal compounds. Many plants are known to have nematicidal properties which may be utilized as

Table. 4. Effect of macerated leaves of some plants on juvenile penetration of *Meloidogyne incognita* in brinjal roots.

Treatments	Plant parts used	Dose (µg/g sand)	Mean numbers of actual J2 penetrated in brinjal roots at a given number of days after inoculation	
			3 days	5 days
Parthenium hysterophorus	**Whole plant**	**0.1**	38 (62)	41(59)
		0.2	33 (67)	36 (64)
		0.3	29 (71)	33 (67)
Cymbopogon citratus	**Leaves**	**0.1**	43 (57)	45 (55)
		0.2	40 (60)	43 (57)
		0.3	36 (64)	39 (61)
Eichhornia crassipes	**Leaves**	**0.1**	46 (54)	47 (53)
		0.2	43 (57)	44 (56)
		0.3	38 (62)	42 (58)
Monstera diliciosa	**Leaves**	**0.1**	49 (51)	51 (49)
		0.2	47 (53)	49 (51)
		0.3	42 (58)	46 (54)
Tinospora cardifolia	**Leaves**	**0.1**	53 (47)	52 (48)
		0.2	49 (51)	50 (50)
		0.3	44 (56)	47 (53)
UIC	_	_	62 (38)	67 (33)

Each value is an average of three replicates
UIC- Untreated inoculated control
Values for percent reduction in J2 penetration in brinjal roots are given in parenthesis.

organic amendments or bio-pesticides. Many scientists have carried out the research on plant extracts for the management of root-knot nematodes.

Acknowledgment

The research was funded by the deanship of scientific research at Princess Nourah bint Abdulrahman University through the fast track research funding group.

Conflict of Interest

The authors declare no conflict of interest.

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