MANAGEMENT OF THE ROOT-KNOT NEMATODE *MELOIDOGYNE INCOGNITA* IN TEA BY TWO PLANT EXTRACTS, IN TRIPURA, INDIA

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Summary. Experiments were undertaken under *in vitro* and *in vivo* conditions to assess the nematicidal activity of the indigenous medicinal plants *Glycosmis pentaphylla* and *Holarrhena antidysenterica* on *Meloidogyne incognita*. Leaf extract of *G. pentaphylla* and bark of *H. antidysenterica* showed strong nematicidal properties. Different concentrations (20, 10, 5, 1, 0.5%) of *G. pentaphylla* leaf extract showed greater ovicidal activity on the egg masses and larvicidal activity on juveniles of *M. incognita* (98.1% to 35.9% inhibition) than those of bark extract of *H. antidysenterica* (84.3% to 28.3% inhibition) at the same concentration. The percentage mortality of the nematode juveniles increased with the rise in concentration of the plant extracts and time of exposure. Amendment of the soil with chopped leaves of *G. pentaphylla* reduced the reproduction of *M. incognita* and improved growth of tea more than did bark extract of *H. antidysenterica*.

Key words: Control, *Camellia sinensis, Glycosmis pentaphylla, Holarrhena antidysenterica*, nematicidal activity, plant extracts.

Considerable research has been carried out on the management of plant parasitic nematodes using different approaches, particularly by synthetic nematicides. Although fumigants are very effective, they have been banned in some countries or restricted in use due to serious threat to soil and environment pollution.

Much less work has been reported on the use of plant extracts to control plant parasitic nematodes. Aqueous extracts and decomposition products of various indigenous medicinal plants possessing anthelminthic properties against plant parasitic nematodes were reported by D'Addabo (1995), Sasanelli (1995), Dasgupta (1998), Nath and Mukherjee (2000), Prasad *et al*. (2002), Sundararaju and Cannayane (2002) and Sosamma and Jayasree (2002).

To expand the choice of non-chemical management tactics, the search for botanicals against plant parasitic nematodes is gaining interest. In the present study, parts of two locally available plants, namely the leaves of *Glycosmis pentaphylla* (Retz.) D.C. (Family - Rutaceae) and bark of *Holarrhena antidysenterica* (Linn.) Wall (Family - Apocynaceae) were used to assess their nematicidal effects against *Meloidogyne incognita* (Kofoid *et* White) Chitw., both *in vitro* and *in vivo*, using tea plants as hosts.

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MATERIALS AND METHODS

The aqueous extracts were prepared from chopped freshly collected plant materials (bark of *H. antidysenterica* and leaves of *G. pentaphylla*), using 20, 10, 5, 1 and 0.5 g of material comminuted in an electric blender in 100 ml distilled water for five minutes. The extracts thus obtained were then passed through a two-layered silk cloth and centrifuged at 5,000 rpm for 10 min. The supernatants were separated and filtered through a Whatman filter paper and used as stock solutions.

A monoclonal stock culture of *M. incognita* was reared on tea (*Camellia sinensis* L.) clone

TV-9 growing in sterile soil in clay pots.

In vitro experiment

To assess the ovicidal activity of the extracts, three egg masses of equal size, each containing 350-400 eggs, were placed in glass cavity blocks (4 cm × 4 cm) and 2 ml aqueous extract of the different concentrations of the plant parts were added. Distilled water (2 ml) in separate cavity blocks containing the same number of egg masses served as a non-treated control. Each treatment was replicated three times and set out in a completely randomized design. The egg masses were incubated in each concentration for five days and then transferred to distilled water. The numbers of freshly emerged juveniles (J_2) from the egg mass were recorded up to 19 days (5 days in the extracts and 14 days in distilled water), i.e. until egg hatching stopped (Sasanelli and D'Addabbo, 1993). The experiment was conducted under laboratory conditions at 23 ± 2 °C.

To assess the activity against juveniles, 50 freshly emerged J_2 of *M. incognita* were placed in a single drop

Table I. Effect of extract from leaves of *Glycosmis pentaphylla* on the hatching of eggs in egg masses of *Meloidogyne incognita*.

Treatment (concentration %)	Mean number of juveniles hatched after (days)*								Total hatch	Mean hatch per egg-mass	% inhibition
	5	7	9	11	13	15	17	19			
20	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	9.4 (3.2)	2.7 (1.9)	3.3 (2.0)	4.0 (2.2)	0.0 (1.0)	19.5	6.5	98.1
10	0.0 (1.0)	0.0 (1.0)	13.3 (3.7)	27.3 (5.3)	61.3 (7.8)	18.5 (4.4)	8.3 (3.0)	1.6 (1.6)	130.5	43.5	87.3
5	5.6 (2.5)	4.8 (2.4)	36.5 (6.1)	108.8 (10.4)	167.8 (12.9)	25.3 (5.1)	12.6 (3.6)	2.4 (1.8)	364.0	121.3	64.8
1	11.8 (3.5)	54.7 (7.4)	157.4 (12.5)	186.2 (13.6)	90.7 (9.5)	59.2 (7.7)	9.4 (3.2)	0.0 (1.0)	569.4	189.8	44.9
0.5	104.2 (10.2)	98.3 (9.9)	248.4 (15.7)	137.3 (11.7)	41.2 (6.5)	31.3 (5.6)	2.2 (1.7)	0.0 (1.0)	663.0	221.0	35.8
Control	285.6 (16.9)	107.3 (10.4)	315.3 (17.7)	173.7 (13.2)	80.2 (9.0)	55.3 (7.5)	12.3 (3.6)	4.3 (2.3)	1034.0	344.6	0.0
SEM	1.23	0.66	1.32	1.23	0.82	0.10	0.07	0.003			
F value	98.56	87.57	106.55	44.74	48.90	133.20	25.42	300.00			
CD at 5%	2.72	1.99	2.81	2.72	2.21	0.75	0.63	0.12			

*Egg masses immersed in extract for 5 days and then transferred to distilled water; control egg masses remained in distilled water throughout the experiment.
Figures in parenthesis are transformed means calculated using the formula √ (x +1).

Table II. Effect of extract from bark of *Holarrhena antidysenterica* on the hatching of eggs in egg masses of *M. incognita*.

Treatment (concentration %)	Mean number of juveniles hatched after (days)*								Total hatch	Mean hatch per egg-mass	% inhibition
	5	7	9	11	13	15	17	19			
20	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	5.8 (2.6)	55.4 (7.5)	74.0 (8.6)	15.6 (4.0)	4.7 (2.4)	155.6	51.8	84.2
10	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	8.3 (3.0)	167.4 (12.9)	76.9 (8.8)	29.6 (5.5)	3.6 (2.1)	286.0	95.3	71.0
5	5.1 (2.4)	0.0 (1.0)	52.6 (7.3)	162.1 (12.7)	94.6 (9.7)	68.6 (8.3)	24.3 (5.0)	2.2 (1.7)	409.7	136.5	58.5
1	7.4 (2.8)	65.6 (8.1)	88.9 (9.4)	76.4 (8.7)	269.6 (16.4)	78.6 (8.9)	44.7 (6.7)	1.4 (1.5)	633.0	211.0	35.9
0.5	60.2 (7.8)	44.3 (6.7)	98.1 (9.9)	246.8 (15.7)	150.9 (12.3)	69.4 (8.3)	34.6 (5.9)	3.3 (2.0)	708.0	236.0	28.3
Control	214.5 (14.6)	176.3 (13.3)	278.4 (16.7)	185.1 (13.6)	90.3 (9.5)	23.6 (4.9)	14.3 (3.9)	5.6 (2.5)	988.2	320.4	0.0
SEM	2.38	2.32	1.62	3.59	4.25	0.54	0.18	0.006			
F value	34.72	32.02	84.30	25.38	7.04	12.66	19.94	68.33			
CD at 5%	3.78	3.75	3.12	7.24	5.09	1.81	1.03	0.72			

*Egg masses immersed in extract for 5 days and then transferred to distilled water; control egg masses remained in distilled water throughout the experiment.
Figures in parenthesis are transformed means calculated using the formula √ (x + 1).

of distilled water in a watch glass immediately followed by the addition of 2 ml of aqueous solution of each concentration of the plant extracts. The non-treated control contained only distilled water. Each treatment was replicated three times and set out in a completely randomized design. Juvenile mortality was determined at half-hour intervals for a period of 6 h and the cumulative mortality was calculated. After treatment, mortality was checked by transferring the immobile nematodes into distilled water for 1 h. Juveniles that did not show motility even after stimulation with a needle were considered dead. The numbers of motile and dead J_2 were counted.

***In vivo* pot experiment**

Clay pots (28 cm diameter) were filled with 4 kg of a solarized (for 20 days), steam sterilized mixture of sandy clay soil and cow dung manure (3:1), mixed thoroughly with different doses (10, 20, 40, 80 g per kg soil) of freshly collected chopped plant parts (bark of *H. antidysenterica* and leaves of *G. pentaphylla*). A treatment with Carbofuran 3G at 3 g per kg of soil along with a non-treated control were included. The pots were irrigated regularly to ensure thorough decomposition of the organic additives. There were three replicates for each treatment according to a completely randomized design. After 25 days, six-month-old tea seedlings (cv. TV-9) at the 6-8 leaf stage were transplanted singly into each pot. After one month, the plants were inoculated with 5,000 freshly emerged juveniles (J_2) of *M. incognita*. The pots were irrigated at regular intervals. The experiment was conducted outdoor at 25 ± 5 °C.

Twenty-four months after inoculation, the plants were carefully uprooted. Roots were gently washed and dried with blotting paper to remove excess water. Fresh plant growth variables, such as shoot and root lengths, shoot and root weights, numbers of leaves, leaf volume, leaf weight, leaf length, leaf width and leaf area were measured. Numbers of root-galls per plant were counted and 20 individual galls from each plant were measured at random to determine their mean size.

To estimate the final population density (*Pf*), the soil from each pot was thoroughly mixed and a 250 cm^3 sub-sample was processed combining the Cobb's decanting and sieving method with a modification of the Baermann's funnel technique. This consisted in using a double layered facial tissue paper supported by a wire mesh assembled in a Petri dish. The nematode suspension was heat relaxed and killed in a hot water bath at 60 °C for 2 minutes and fixed in double strength solution of FAA (formaldehyde acetic acid). Nematode specimens in the suspensions were counted under binocular microscope. Also, the roots were cut in 0.5-1 cm long pieces, mixed and three sub-samples (1 g each) were stained in boiling acid fuchsin in lactophenol and then blended for one minute. The nematode specimens in the suspension were counted using a binocular microscope. Then the reproduction rate of the nematode was calculated as the ratio between the final nematode population density (in soil and roots) and the initial population (*Pf/Pi*) according to Oostenbrink (1966).

Statistical analysis. The data from the two experiments were subjected to analysis of variance (ANOVA) and standard deviations and critical differences (CD) at P = 0.05 were calculated.

RESULTS

In vitro *experiment*

Ovicidal activity of G. pentaphylla. Leaf extract of *G. pentaphylla* showed strong nematicidal activity. Immersion of egg masses in a 20% concentration of the leaf extract completely suppressed hatching up to 5 days and this effect continued for a further four days (over the 7th and 9th days) after transferring egg masses to distilled water (Table I). Similar hatching behaviour was shown by egg masses immersed in a 10% concentration of the same extract up to the 7th day. Total egg hatch in distilled water was more than 53 times that in a 20% concentration of the leaf extract, indicating a strong ovicidal effect of the aqueous extract. The average number of emerging juveniles ranged from 0 to 104 in 20% to 0.5% concentrations of leaf extract over the 5 days of exposure, compared to the 285 juveniles that emerged in the control over the first 5 days. Initially, hatching was completely suppressed by the higher concentrations of the leaf extract (10 and 20%), and it remained negligible later (11th and 13th days). On the contrary, in the lower concentrations (0.5, 1 and 5%), the inhibitory effects started gradually and a larger number of juveniles emerged from the 9th to the 13th days. Later, the numbers of emerging juveniles decreased and were very low or nil at all concentrations by the 19th day. The mean total numbers of emerged juveniles ranged from 6 to 221 per egg mass by the 19th day, when egg hatching had stopped, compared to 344 J_2 per egg mass in the control. All extract concentrations suppressed emergence of juveniles and the percentage hatch inhibition ranged from 98.1 to 35.9% relative to the control. About 45% hatching inhibition occurred at a 1% concentration of *G. pentaphylla* leaf extract.

Ovicidal activity of H. antidysenterica. Concentrations of 20 and 10% of aqueous extract of bark of *H. antidysenterica* completely suppressed emergence of juveniles up to nine days (Table II). Total egg hatch in distilled water was more than six times higher than that in a 20% concentration of the bark extract, indicating a strong ovicidal effect. The average emergence of juveniles up to 5 days ranged from 0 to 60% at 20 to 0.5% concentrations of bark extract compared to 214 juveniles that emerged in the control.

The greatest numbers of juveniles emerged from the control between the 7th and 11th day. In bark extract,

Table III. Effect of extract from leaves of *G. pentaphylla* on mortality of juveniles of *M. incognita*.

Treatment (concentration %)	Mean % mortality at 0.5 hour intervals										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
20	35.0 (36.2)	60.0 (50.7)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)
10	5.0 (19.9)	28.3 (32.1)	73.5 (59.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)
5	3.3 (10.4)	18.3 (25.3)	55.3 (48.0)	76.3 (60.8)	90.3 (71.8)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)
1	0.0 (0.0)	0.0 (0.0)	8.3 (16.7)	21.6 (27.7)	26.6 (31.0)	45.0 (42.1)	58.3 (49.7)	83.3 (65.9)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)
0.5	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	8.3 (16.7)	13.3 (21.4)	21.6 (27.7)	31.6 (34.2)	41.6 (40.1)	48.3 (44.0)	60.0 (50.7)	60.0 (50.7)
Control	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
SEM	17.56	16.58	15.41	27.40	5.54	3.54	13.59	12.79	0.82	0.05	1.32
F value	31.95	83.52	255.59	162.56	797.33	1287.6	312.19	313.9	5199.23	79105.73	3116.01
CD at 5%	10.36	10.05	9.69	12.93	5.81	4.63	9.09	25.81	2.24	0.54	2.66

Values in parenthesis are angular transformed value of the means.

Table IV. Effect of extract from bark of *H. antidysenterica* on mortality of juveniles of *M. incognita*.

Treatment (concentration %)	Mean % mortality at 0.5 hour intervals								
	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
20	50.0 (45.0)	68.3 (55.7)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)
10	0.0 (0.0)	16.6 (24.0)	30.0 (33.2)	43.3 (41.1)	60.0 (50.7)	76.6 (61.1)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)
5	0.0 (0.0)	0.0 (0.0)	21.6 (27.7)	38.3 (38.2)	53.3 (46.9)	65.8 (54.2)	88.3 (65.9)	100.0 (90.0)	100.0 (90.0)
1	0.0 (0.0)	0.0 (0.0)	8.3 (16.7)	16.6 (24.0)	25.0 (30.0)	35.0 (36.2)	46.6 (43.0)	58.3 (49.7)	70.0 (56.7)
0.5	0.0 (0.0)	0.0 (0.0)	6.6 (54.6)	13.3 (21.4)	21.6 (27.7)	26.6 (31.0)	36.6 (37.2)	43.3 (41.1)	51.6 (45.9)
Control	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
SEM	0.19	12.18	28.73	19.98	17.62	35.85	22.87	5.01	30.17
F value	5328.26	129.30	102.59	138.17	153.96	78.54	162.66	809.66	128.75
CD at 5%	1.06	24.60	13.24	11.02	10.36	14.78	11.81	5.51	13.57

Values in parenthesis indicate angular transformed value of the means.

hatching was greatly suppressed by the higher concentrations (10 and 20%), but later (13th and 15th days) it increased. In the lower concentrations (0.5, 1 and 5%), the inhibitory effect started gradually and a greater number of juveniles emerged on the 11th and 13th days. The mean total number of juveniles emerged ranged from 51.9 to 236 per egg mass at 19 days, when egg hatching had stopped, compared to 320 J_2 per egg mass in the non-treated control. In all concentrations of the bark extract, egg hatch was inhibited and percent inhibition ranged from 84 to 28 relative to the control. About 36% hatching inhibition occurred at a 1% concentration.

Larvicidal activity of leaf extract of G. pentaphylla. Complete mortality of juveniles was recorded after 2, 2.5, and 3.5 h at concentrations of 20, 10 and 5%, of the leaf extract, whilst 58.3 and 31.7% juvenile mortality occurred at 1 and 0.5% concentrations after 4 h, respectively (Table III). At lower concentrations, the percent mortality increased slowly and gradually, and 100% and 60% of the juveniles were killed by 1 and 0.5% concentrations up to five and six hours, respectively (Table III). No mortality was observed in the control.

Larvicidal activity of bark extract of H. antidysenterica. All juveniles were found dead (Table IV) after 3, 5 and 5.5 h in 20, 10 and 5% bark extract, respectively, whilst 70 and 51.7% mortality occurred with 1 and 0.5% concentrations after 6 h. The results showed that percentage mortality increased with increase in concentration of the bark extract and of the exposure time. No mortality occurred in the control.

In vivo *pot experiment*

Effect of G. pentaphylla *on tea plants*. The root-knot nematode multiplied well on tea plants in the non-treated control (Table V). All amendments suppressed the development of root-galls, size of galls and nematode population density. There were increases in the growth variables (shoot and root length, shoot and root weight, number of leaves, leaf volume and leaf weight) of the treated tea plants with a parallel increase in the rate of the amendment. The reproduction rate of the nematode decreased with increase in the rate of organic amendments used. It was less than one in all treatments and significantly smaller than that in the inoculated non-treated control.

Effect of barks of H. antidysenterica *on tea plants*. The nematode multiplied well on the inoculated non-treated control tea plants. The development of root-galls, size of galls and nematode reproduction were suppressed at all rates tested. The reproduction rates of the nematode decreased with increase in the rate of the organic amendment; it was less than one in all treatments and significantly smaller than that in the inoculated non-treated control. The bark amendment also improved growth of the tea plants.

Table V. Effect of soil amendment with chopped leaves of *G. pentaphylla* on reproduction of *M. incognita* and growth of tea plants.

Treatment (g/kg soil)	Shoot length (cm)	Root length (cm)	Shoot weight(g)	Root weight (g)	No. of leaves	Leaf vol. (ml)	Leaf weight (g)	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2)	Final population (soil + root)	Multiplication rate (Pf/Pi)	No. of galls/root system	Mean size of galls (mm)
10	75.6	23.7	59.4	61.0	41.0	23.3	15.3	13.6	5.0	17.3	92	0.1	58	1.9
	(8.7)	(4.9)	(7.7)	(7.8)	(6.4)	(4.9)	(4.0)	(3.8)	(2.4)	(4.2)	(30.4)	(1.0)	(7.6)	(1.7)
20	97.9	27.7	67.6	65.5	72.5	53.5	32.3	13.4	5.0	16.8	563	0.12	32	2.1
	(9.9)	(5.3)	(8.2)	(8.1)	(8.5)	(7.3)	(5.7)	(3.7)	(2.4)	(4.2)	(23.7)	(1.0)	(5.7)	(1.7)
40	122.8	29.5	133.1	66.3	118.3	86.7	41.1	15.4	5.3	20.5	346	0.07	14	1.7
	(11.1)	(5.5)	(11.5)	(8.2)	(10.9)	(9.3)	(6.4)	(4.0)	(2.5)	(4.6)	(18.6)	(1.03)	(3.8)	(1.6)
80	145.7	28.7	162.8	88.1	162.4	115.3	52.6	15.5	5.1	19.8	460	0.09	09	1.4
	(121.1)	(5.4)	(12.8)	(9.4)	(12.7)	(10.7)	(7.3)	(4.0)	(2.4)	(4.5)	(21.4)	(1.04)	(3.1)	(1.5)
Carbofuran 3G (3 g/kg soil)	83.6	27.9	58.5	65.5	78.2	50.2	27.5	14.9	4.5	16.8	637	0.13	23	1.8
	(9.2)	(5.3)	(7.7)	(8.1)	(8.9)	(7.1)	(5.3)	(3.9)	(2.3)	(4.2)	(25.2)	(1.06)	(4.8)	(1.6)
Control	75.5	23.0	52.8	62.6	52.3	39.2	18.3	11.4	4.8	13.8	12825	2.5	137	2.5
	(8.7)	(4.9)	(7.3)	(7.9)	(7.3)	(6.3)	(4.3)	(3.5)	(2.4)	(3.8)	(113.2)	(1.8)	(11.7)	(1.8)
SEM	4.93	0.03	0.07	0.14	0.03	3.81	1.46	1.01	0.21	0.16	287.99	0.0007	0.40	0.01
F value	1.39	6.66	243.57	6.85	159.72	3.14	2.00	0.10	68.61	1.25	12.26	485.7	72.85	3.0
CD at 05%	0.05	0.42	0.63	0.90	0.42	4.81	2.96	2.48	1.12	0.68	41.96	0.18	1.54	0.24

Values in parenthesis are transformed values of the means calculated using this formula $\sqrt{(x+1)}$.

Table VI. Effect of soil amendment with chopped leaves of *H. antidysenterica* on reproduction of *M. incognita* and growth of tea plants.

Treatment (g/kg soil)	Shoot length (cm)	Root length (cm)	Shoot weight (g)	Root weight (g)	No. of leaves	Leaf vol. (ml)	Leaf weight (g)	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2)	Final population (soil + root)	Multiplication factor (Pf/Pi)	No. of galls/root system	Mean size of galls (mm)
10	73.6 (8.6)	26.7 (5.2)	58.1 (7.6)	51.3 (7.2)	35.0 (6.0)	13.0 (3.7)	12.0 (3.6)	12.8 (3.7)	6.0 (2.6)	19.4 (4.5)	238 (48.8)	0.47 (1.2)	74 (8.6)	2.1 (1.7)
20	84.0 (9.2)	26.5 (5.2)	62.8 (7.9)	51.0 (7.2)	45.0 (6.7)	19.0 (4.4)	15.1 (4.0)	13.4 (3.8)	5.0 (2.4)	17.0 (4.2)	1566 (39.5)	0.31 (1.1)	46 (6.8)	1.8 (1.6)
40	109.2 (10.5)	28.7 (4.4)	71.3 (8.5)	69.3 (8.3)	87.3 (9.3)	67.1 (8.2)	30.5 (4.0)	15.4 (4.0)	5.3 (2.5)	20.4 (4.3)	871 (29.5)	0.17 (1.08)	22 (4.7)	1.3 (1.5)
80	130.7 (11.4)	32.0 (5.7)	185.7 (13.6)	81.6 (9.0)	106.2 (10.3)	80.3 (9.0)	36.8 (6.1)	15.2 (4.0)	5.1 (2.4)	19.6 (4.5)	257 (16.0)	0.05 (1.02)	12 (3.6)	1.6 (1.6)
Carbofuran 3G (3 g/kg soil)	83.6 (9.2)	27.9 (5.3)	58.5 (7.7)	65.5 (8.1)	78.2 (8.9)	50.2 (7.1)	27.5 (5.3)	14.9 (3.9)	4.5 (2.3)	16.8 (4.2)	637 (25.2)	0.13 (1.06)	23 (4.8)	1.8 (1.6)
Control	75.5 (8.7)	23.0 (4.9)	52.8 (7.3)	62.8 (7.9)	52.3 (7.3)	39.2 (6.3)	18.3 (4.3)	11.4 (3.5)	4.8 (2.4)	13.8 (3.8)	10825 (104.0)	2.56 (1.8)	137 (11.7)	2.5 (1.8)
SEM	44.27	1.18	10.19	0.11	1.24	0.44	0.59	0.07	0.14	0.18	395.04	0.11	0.80	0.07
F value	1.75	0.22	0.84	14.09	6.48	29.43	4.76	2.57	0.21	0.72	20.89	0.09	34.46	28.57
CD at 5%	16.45	2.66	7.87	0.81	2.72	1.63	1.87	0.006	0.009	0.72	49.12	0.81	2.21	0.006

Figures in parenthesis are transformed means calculated using this formula √x+1.

DISCUSSION

The leaves of *G. pentaphylla* are mainly used as a remedy for cure of human helminth infections, particularly among children, in Ayurvedic medicine. Moreover, the juices of leaves are also used in fever and liver complaints and as a vermifuge. Leaves are considered to be a good antidote for eczema and other skin troubles when applied as a paste (Ramachandran *et al*., 1986). The leaf extract of this medicinal plant had already been reported to possess nematicidal activity against *Radopholus similis* Cobb (Jasy and Koshy, 1992). In our study, the inhibitory effect of *G. pentaphylla* was demonstrated as reduction in size and number of root galls in tea. Ibrahim (2002) demonstrated that the numbers of galls, egg masses and eggs/g fresh root had positive linear relationships to Pi, with *r* ranging from 0.72 to 0.96 in treated tomato plants. Although working with different plant sources, the effects on hatching and mortality obtained by Nath and Mukherjee (2000) and Sundararaju and Cannayane (2002) were similar to our results, but the nematicidal effect of the plant extracts used in our experiment was much faster. Moreover, organic amendments enhance biological suppression of plant parasitic nematodes (Widmer *et al*., 2002; Stirling *et al*., 2003).

The bark of *H. antidysenterica*, known as conessi bark, is antihelminthic, stomachic, antipyretic, tonic and antidysenteric, used in amoebic dysentery and diarrhoea. It contains the alkaloid conessine, a gum resin and tannin (Ramachandran *et al*., 1986). It also possesses a strong nematicidal activity that has been demonstrated by suppression of hatching and juvenile mortality.

The aqueous extracts of various plant parts (root, leaf, bark and floral parts) of indigenous medicinal plants possess nematicidal properties (Jairajpuri *et al*., 1990; Sukul, 1994; Dasgupta, 1998; Maistrello *et al*., 2010; Caboni *et al*., 2012; Renco *et al*., 2012). The present study showed that the decomposition products of the two plant materials used have hatching inhibitor effects and killed nematode juvenile. Therefore, it should be possible for them to be used successfully in root-knot nematode management and also as a source of green manure in tea nurseries.

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