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**EFFICACY OF SOME PLANT EXTRACTS AGAINST ROOT-KNOT (*Meloidogyne javanica*) OF CHILLI**

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EFFICACY OF SOME PLANT EXTRACTS AGAINST ROOT-KNOT (*Meloidogyne javanica*) OF CHILLIR.K. SINGHA<sup>1</sup>, S.M.E. HASSAN<sup>2</sup>, M.M. ISLAM<sup>1</sup>, N.B. ISLAM<sup>1</sup> AND S.M.M. HOSSAIN<sup>2\*</sup><sup>1</sup>MS Student, Department of Plant Pathology, HSTU, Dinajpur; <sup>2</sup>Professor, Department of Plant Pathology, HSTU, Dinajpur.

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## ABSTRACT

Singha RK, Hassan SME, Islam MM, Islam NB, Hossain SMM (2016) Efficacy of some plant extracts against root-knot (*Meloidogyne javanica*) of chilli. *Int. J. Sustain. Crop Prod.* 11(3), 12-19.

The standard (S) and half-standard (S/2) leaf extract of Bermuda grass, Water spinach, Ivy leaf morning glory, Nisinda, and Justicia were tested against root-knot of chilli caused by *Meloidogyne javanica* in pot experiment after 10 days of transplantation. Among the plant extracts, standard (S) extract of Bermuda grass followed by Water spinach gave superior result as it had increased shoot and root length as well as fresh weight of shoot and root respectively with the lowest galling incidence and development of adult female, J<sub>2</sub>, J<sub>3</sub> and J<sub>4</sub> juveniles of *Meloidogyne javanica* in chilli. Comparatively better effect on plant growth characters with lower galling incidence and development of the nematode was observed with standard (S) extract of Ivy leaf morning glory leaf followed by standard (S) extract of Nisinda leaf. Half-standard (S/2) extract of Bermuda grass also gave promising result on plant growth characters with lower galling incidence and development of the nematode. Comparatively lower effect of plant growth character was found with half-standard (S/2) extract of Water spinach leaf followed by half-standard (S/2) extract of Ivy leaf morning glory leaf. Half standard (S/2) extracts of Nisinda and Justicia leaf were also found effective as compared to control.

**Key words:** root-knot, plant extract, meloidogyne, chilli

## INTRODUCTION

Chilli (*Capsicum frutescens*) is one of the leading spices of Bangladesh, which contain capsaicin, an alkaloid used in many pharmaceutical preparations (Pruthi 1979). In 2013, the acreage of chilli was 94 thousand hectare and the production was 102,000 metric tons in Bangladesh (BBS 2014). On a global basis, out of the approximately 35% crop losses annually caused by crop enemies; 12% is due to diseases caused by fungi, bacteria and viruses, 11% is due to diseases caused by nematodes, 7% is due to insects and 3% is due to weeds (Cramer 1967). According to Sasser and Freckman (1987) the annual loss of crops due to nematode is about 12.3%. Loss in chilli due to nematode is 12.2% (Singh 2005). The soil and climatic condition of Bangladesh has made her an ideal abode for nematodes.

Several hundred species of nematodes are known to feed on living plants as parasite causing a variety of plant diseases. From a preliminary survey, it was found that 15 genera of plant parasitic nematodes are associated with commercial crops in Bangladesh where root-knot nematode (*Meloidogyne* spp.) were the most abundant and wide spread (Timm and Ameen, 1960 and Ahmad 1977). The root-knot disease is of economic importance to the chilli growers in spices crops; the loss is increased because root-knot nematode predisposes the plants for further injury by other micro-organisms. At present, root-knot nematode is a great threat because of its wide distribution, polyphagous nature and ability to complete several generations in a crop season. Many biocontrol agents are used to manage nematode population. Existing practice of chemical control is too costly and also a difficult task for the common farmers to determine the precise dose of the chemical for its application to the field. In addition, their harmful effect is responsible for air, soil and water pollution (Alam 1987). A good number of nematicides are used in developed countries but in Bangladesh only a few of those are imported and marketed in small quantities and sold at high price. On the other hand, plant extracts are cheap, available, easy to prepare, effective and environment friendly. Control of nematode diseases of plants with extracts of leaves is relatively a new approach of disease control by biological means. Different plants extracts like *Eucalyptus* sp., (Dawar *et al.* 2007), *Avicennia marina*, *Rhizophora mucronata*, *Cerriops tagal* and *Aegiceras corniculatum* were effective against root knot nematode (Mehdi and Dawar, 2008; Saifullah and Gui, 1990 and Ahmad *et al.* 1991). With this view in mind, the present research work has been undertaken to evaluate the effectiveness of Bermuda grass (*Cynodon dactylon*), Water spinach (*Ipomoea aquatica*), Ivy leaf morning glory (*Ipomoea hederacea*), Nisinda (*Vitex negundo*) and Justicia (*Justicia gendarussa*) against root-knot of chilli and to determine the dose and superior extract for controlling root-knot of chilli in the northern region of Bangladesh.

## MATERIALS AND METHODS

The pot experiment was carried out with Standard (S) and half-standard (S/2) concentration of different plant extracts applied after 10 days of transplantation. At first, sandy loam soil, sand and well decomposed cowdung were collected and mixed properly at the ratio of 2: 2:1. The mixed soil was sterilized with formalin at the rate of 3% per cubic feet soil. Then earthen pots (30 cm diameter) were washed with water and sterilized with formalin and filled with 4 kg sterilized and dried soil. Before sowing, collected seeds were surface sterilized with low concentration of mercuric chloride solution (0.001%) for 1 minute and subsequently washing was done with clean water for thrice. Seeds of chilli were sown in separate big earthen pot (50 cm diameter) with sterilized soil and treated as seed beds. Seedling of chilli at the age of 35 days was transplanted in each earthen

pot (30 cm diameter). Ten reddish brown mature egg masses were inoculated in each pot around the standing plant in 2 holes (2.5 cm deep), five egg masses on each side of the plant.

The twenty five gram of Bermuda grass was macerated in an electric blender and soaked separately in 100 ml distilled water in several conical flask and was kept for 24 hours and then it was filtered. Thus, these filtrates treated as standard (S). Subsequent dilution with the addition of required distilled water, half-standard (S/2) concentration of Bermuda grass extract was prepared. The same procedure was followed in the preparation of standard (S) and half-standard (S/2) of Water spinach, Ivy leaf morning glory, Nisinda and Justicia leaf extract. Leaf extracts used were as T<sub>0</sub> = Control (without extract), T<sub>1</sub> = 25 ml Justicia leaf (S) extract, T<sub>2</sub> = 25 ml Justicia leaf (S/2) extract, T<sub>3</sub> = 25 ml Nisinda leaf (S) extract, T<sub>4</sub> = 25 ml Nisinda leaf (S/2) extract, T<sub>5</sub> = 25 ml Ivy leaf morning glory leaf (S) extract, T<sub>6</sub> = 25 ml Ivy leaf morning glory (S/2) extract, T<sub>7</sub> = 25 ml Water spinach leaf (S) extract, T<sub>8</sub> = 25 ml Water spinach leaf (S/2) extract, T<sub>9</sub> = 25 ml Bermuda grass leaf (S) extract, T<sub>10</sub> = 25 ml Bermuda grass leaf (S/2) extract. Plant extract was applied to the respective pot plants just after 10 days of transplantation. After 30, 60 and 90 days of inoculation, plants were uprooted carefully to study the following characters: Length of shoot, Length of root, Fresh weight of shoot, Fresh weight of root and Number of gall/g fresh root. Staining of gall roots was performed to count the nematode population. The experiment was conducted in completely randomized design with three replications. Collected data were analyzed statistically to find out the level of significance. The mean differences were evaluated at P = 0.05 level by Duncan's New Multiple Range Test.

## RESULTS

### Effect of different treatments on the growth and galling incidence of chilli inoculated with *Meloidogyne javanica* after 10 days of transplantation at 30 days of inoculation

The highest shoot length 37.33 cm was recorded with Bermuda grass (T<sub>9</sub>) extract followed by Water spinach leaf (T<sub>7</sub>) extract having 35.43 cm (Table 1). Ivy leaf morning glory leaf (T<sub>5</sub>) extract gave comparatively higher shoot length 32.64 cm followed by Nisinda leaf (T<sub>3</sub>) extract having 29.67 cm. Higher but similar effect on shoot length was observed with Justicia leaf (T<sub>1</sub>) extract and Bermuda grass (T<sub>10</sub>) having 28.00 cm and 27.00 cm, respectively. Comparatively lower shoot length 25.33 cm was found with Water spinach leaf (T<sub>8</sub>) extract. Ivy leaf morning glory leaf (T<sub>6</sub>) extract, Nisinda leaf (T<sub>4</sub>) extract and Justicia leaf (T<sub>2</sub>) extract were recorded with lower and similar response on shoot length having 22.67 cm, 21.33 cm and 20.33 cm, respectively; while the lowest shoot length 17.33 cm was recorded with non-treated control (T<sub>0</sub>) treatment. Bermuda grass (T<sub>9</sub>) extract resulted the highest root length 30.67 cm followed by Water spinach leaf (T<sub>7</sub>) extract and Ivy leaf morning glory leaf (T<sub>5</sub>) extract having 28.33 cm and 27.67 cm, respectively (Table 1). Comparatively higher root length was observed with Nisinda leaf (T<sub>3</sub>) extract having 25.43 cm. Higher and identical response in root length was noted with Justicia leaf (T<sub>1</sub>) extract, Bermuda grass (T<sub>10</sub>) extract and Water spinach leaf (T<sub>8</sub>) extract having 21.80 cm, 21.67 cm and 20.33 cm, respectively. Ivy leaf morning glory leaf (T<sub>6</sub>) extract and Nisinda leaf (T<sub>4</sub>) extract were noted with comparatively lower but identical response in root length having 17.67 cm and 16.67 cm, respectively. Justicia leaf (T<sub>2</sub>) extract was exhibited with lower root length 14.77 cm; while the lowest root length 11.50 cm was recorded with the control (T<sub>0</sub>) treatment. The highest fresh shoot weight 28.40 g was recorded with Bermuda grass (T<sub>9</sub>) extract followed by Water spinach leaf (T<sub>7</sub>) extract 26.40g (Table 1). Ivy leaf morning glory leaf (T<sub>5</sub>) extract was found with comparatively higher fresh shoot weight 24.30 g followed by Nisinda leaf (T<sub>3</sub>) extract 22.33 g. Higher but identical response in fresh shoot weight was recorded with Justicia leaf (T<sub>1</sub>) extract and Bermuda grass (T<sub>10</sub>) extract having shoot weight 20.33 g and 20.00 g, respectively. Water spinach leaf (T<sub>8</sub>) extract was found with comparatively lower fresh shoot weight 18.33 g followed by Ivy leaf morning glory leaf (T<sub>6</sub>) extract having 16.37 g. Lower fresh shoot weight 14.30 g was appeared with Nisinda leaf (T<sub>4</sub>) extract followed by Justicia leaf (T<sub>2</sub>) extract having 12.33 g. The control (T<sub>0</sub>) treatment showed the lowest shoot weight 9.36 g. In case of fresh weight of root, Bermuda grass (T<sub>9</sub>) extract caused the highest root weight 18.33 g (Table 1). Relatively higher fresh weight of root was recorded with Water spinach leaf (T<sub>7</sub>) extract having 16.33 g. Ivy leaf morning glory leaf (T<sub>5</sub>) extract, Nisinda leaf (T<sub>3</sub>) extract, Justicia leaf (T<sub>1</sub>) extract and Barmuda grass (T<sub>10</sub>) extract were found with higher and identical response having root weights 14.33 g, 13.17 g, 12.17 g and 12.00 g, respectively. Lower but similar response in root weight was noted with Water spinach leaf (T<sub>8</sub>) extract, Ivy leaf morning glory leaf (T<sub>6</sub>) extract, Nisinda leaf (T<sub>4</sub>) extract and Justicia leaf (T<sub>2</sub>) extract having 10.33 g, 10.00 g, 9.33 g and 8.17 g root weight, respectively. The lowest 6.33 g fresh root weight was recorded in control (T<sub>0</sub>) treatment. In case of fresh weight of root, Bermuda grass (T<sub>9</sub>) extract caused the highest root weight 18.33 g (Table 1). Comparatively higher fresh weight of root was recorded with Water spinach leaf (T<sub>7</sub>) extract having 16.33 g. Ivy leaf morning glory leaf (T<sub>5</sub>) extract, Nisinda leaf (T<sub>3</sub>) extract, Justicia leaf (T<sub>1</sub>) extract and Barmuda grass (T<sub>10</sub>) extract were found with higher and identical response having root weights 14.33 g, 13.17 g, 12.17 g and 12.00 g, respectively. Lower but similar response in root weight was noted with Water spinach leaf (T<sub>8</sub>) extract, Ivy leaf morning glory leaf (T<sub>6</sub>) extract, Nisinda leaf (T<sub>4</sub>) extract and Justicia leaf (T<sub>2</sub>) extract having 10.33 g, 10.00 g, 9.33 g and 8.17 g root weight, respectively. The lowest 6.33 g fresh root weight was recorded in control (T<sub>0</sub>) treatment. In case of galling, the highest 19.67 gall/g root was recorded with control

(T<sub>0</sub>) treatment (Table 1). Comparatively higher and similar effect of gall/g root was recorded with Justicia leaf (T<sub>2</sub>) extract and Nisinda leaf (T<sub>4</sub>) extract having 16.67 and 16.67 gall/g root, respectively. Ivy leaf morning glory leaf (T<sub>4</sub>) extract and Water spinach leaf (T<sub>8</sub>) extract were found with higher but identical response having 15.00 and 14.67 gall/g root, respectively. Comparatively lower 12.67 gall/g root was found with Bermuda grass (T<sub>10</sub>) followed by Justicia leaf (T<sub>1</sub>) extract having 10.67 gall/g root. Nisinda leaf (T<sub>3</sub>) extract was recorded with lower 8.67 gall/g root followed by Ivy leaf morning glory leaf (T<sub>5</sub>) extract and Water spinach leaf (T<sub>7</sub>) extract having 6.67 and 4.67 gall/g root. Bermuda grass (T<sub>9</sub>) extract was noted significantly with the lowest 2.67 gall/g root (Table 1).

Table 1. Effect of different treatments on the growth and galling incidence of chilli inoculated with *Meloidogyne javanica* after 10 days of transplantation at 30 days of inoculation

Treatments	Length of shoot (cm)	Length of root (cm)	Fresh weight of shoot (g)	Fresh weight of root (g)	No. of gall / g root
T <sub>0</sub>	17.33 i	11.50 h	9.36 j	6.33 g	19.67 a
T <sub>1</sub>	28.00 e	21.80 d	20.33 e	12.17 d	10.67 e
T <sub>2</sub>	20.33 h	14.77 g	12.33 i	8.17 f	16.67 b
T <sub>3</sub>	29.67 d	25.43 c	22.33 d	13.17 cd	8.67 f
T <sub>4</sub>	21.33 gh	16.67 f	14.30 h	9.33 ef	16.67 b
T <sub>5</sub>	32.64 c	27.67 b	24.30 c	14.33 c	6.67 g
T <sub>6</sub>	22.67 g	17.67 f	16.37 g	10.00 e	15.00 c
T <sub>7</sub>	35.43 b	28.33 b	26.40 b	16.33 b	4.67 h
T <sub>8</sub>	25.33 f	20.33 e	18.33 f	10.33 e	14.67 c
T <sub>9</sub>	37.33 a	30.67 a	28.40 a	18.33 a	2.67 i
T <sub>10</sub>	27.00 e	21.67 de	20.00 e	12.00 d	12.67 d
Lsd	1.44	1.34	1.48	0.66	1.44
SE	1.03	1.03	0.80	0.31	0.93

Data represents the mean of three replications; in a column, values having same letter (s) do not differ significantly at 5% level

#### Effect of different treatments on the growth and galling incidence of chilli inoculated with *Meloidogyne javanica* after 10 days of transplantation at 60 days of inoculation

The highest shoot length 52.33 cm was recorded with Bermuda grass (T<sub>9</sub>) extract followed by Water spinach leaf (T<sub>7</sub>) extract having 50.33 cm (Table 2). Ivy leaf morning glory leaf (T<sub>5</sub>) extract was observed with comparatively higher shoot length 48.37 cm followed by Nisinda leaf (T<sub>3</sub>) extract having 45.43 cm. Higher shoot length and identical response was found with Justicia leaf (T<sub>1</sub>) extract and Bermuda grass (T<sub>10</sub>) extract having 43.37 cm and 43.00 cm, respectively. Water spinach leaf (T<sub>8</sub>) extract gave comparatively lower response in shoot length with 41.33 cm followed by Ivy leaf morning glory leaf (T<sub>6</sub>) extract having 38.40 cm. Lower shoot length 36.37 cm was recorded with Nisinda leaf (T<sub>4</sub>) extract followed by Justicia leaf (T<sub>2</sub>) extract having 35.00 cm; while the lowest shoot length 32.33 cm was appeared with the control (T<sub>0</sub>) treatment. With respect to the length of root, Bermuda grass (T<sub>9</sub>) extract was found to give the highest response having 40.67 cm (Table 2). Comparatively higher but identical response in root length was found with Water spinach leaf (T<sub>7</sub>) extract, Ivy leaf morning glory leaf (T<sub>5</sub>) extract and Nisinda leaf (T<sub>3</sub>) extract having 38.47 cm, 37.40 cm and 36.07 cm, respectively. Justicia leaf (T<sub>1</sub>) extract, Bermuda grass (T<sub>10</sub>) and Water spinach leaf (T<sub>8</sub>) extract were observed with higher but similar effect on root length having 31.83 cm, 31.70 cm and 31.07 cm, respectively. Comparatively lower but statistically equal response in the length of root was recorded with Ivy leaf morning glory leaf (T<sub>6</sub>) extract and Nisinda leaf (T<sub>4</sub>) extract having 27.67 cm and 26.87 cm, respectively. Lower root length 24.67 cm was observed with Justicia leaf (T<sub>2</sub>) extract. The control (T<sub>0</sub>) treatment gave the lowest root length 21.50 cm. Significant variations were found among the treatments with respect to shoot weight. The highest 36.33 g fresh shoot weight was recorded with Bermuda grass (T<sub>9</sub>) extract followed by Water spinach leaf (T<sub>7</sub>) extract having 34.37 g. Ivy leaf morning glory leaf (T<sub>5</sub>) extract was noted with comparatively higher 31.73 g fresh shoot weight. Higher fresh weight of shoot was found with Nisinda leaf (T<sub>3</sub>) extract having 30.33 g. Lower but identical response in fresh shoot weight was observed with Justicia leaf (T<sub>1</sub>) extract, Bermuda grass (T<sub>10</sub>) extract, Water spinach leaf (T<sub>8</sub>) extract, Ivy leaf morning glory leaf (T<sub>6</sub>) extract, Nisinda leaf (T<sub>4</sub>) extract and Justicia leaf (T<sub>2</sub>) extract having 28.40 g, 27.33 g, 26.43 g, 25.33 g, 24.33 g and 23.33 g, respectively. The lowest 20.37 g shoot weight was exhibited with the control (T<sub>0</sub>) treatment (Table 2). The highest fresh weight of root resulted with Bermuda grass (T<sub>9</sub>) extract having 20.33 g (Table 2). Water spinach leaf (T<sub>7</sub>) extract was noted with comparatively higher fresh root weight having 18.27 g. Higher but similar effect on fresh root weight was observed with Ivy leaf morning glory (T<sub>5</sub>) leaf extract, Nisinda leaf (T<sub>3</sub>) extract, Justicia leaf (T<sub>1</sub>) extract and Bermuda grass (T<sub>10</sub>) extract having 16.57 g, 15.33 g 14.33 g and 14.00 g, respectively. Water spinach leaf (T<sub>8</sub>) extract and Ivy leaf morning glory leaf (T<sub>6</sub>) extract were recorded with comparatively lower fresh root weight having 12.33 g and 12.00 g, respectively. Lower but statistically equal response on fresh root weight was found with Nisinda leaf (T<sub>4</sub>) extract and Justicia leaf (T<sub>2</sub>) extract having 10.77 g and 10.36 g,

respectively; while the control (T<sub>0</sub>) treatment was appeared with the lowest 8.17 g fresh root weight. In respect of galling, the control (T<sub>0</sub>) treatment was appeared to give the highest 26.67 gall/g root followed by Justicia leaf (T<sub>2</sub>) extract having 24.67 gall/g root (Table 3). Nisinda leaf (T<sub>4</sub>) extract and Ivy leaf morning glory leaf (T<sub>6</sub>) extract were recorded with comparatively higher but similar effect having 22.67 and 22.67 gall/g root, respectively. Higher 20.67 gall/g root was found with Water spinach leaf (T<sub>8</sub>) extract followed by Bermuda grass (T<sub>10</sub>) extract having 18.67 gall/g root. Justicia leaf (T<sub>1</sub>) extract was recorded with comparatively lower 16.67 gall/g root followed by Nisinda leaf (T<sub>3</sub>) extract having 14.67 gall/g root. Lower 12.67 gall/g root was recorded with Ivy leaf morning glory leaf (T<sub>5</sub>) extract followed by Water spinach leaf (T<sub>7</sub>) extract having 10.67 gall/g root; while the lowest 8.67 gall/g root was noted with Bermuda grass (T<sub>9</sub>) extract.

Table 2. Effect of different treatments on the growth and galling incidence of chilli inoculated with *Meloidogyne javanica* after 10 days of transplantation at 60 days of inoculation

Treatments	Length of shoot (cm)	Length of root (cm)	Fresh weight of shoot (g)	Fresh weight of root (g)	No. of gall / g root
T <sub>0</sub>	32.33 j	21.50 g	20.37 j	8.17 g	26.67 a
T <sub>1</sub>	43.37 e	31.83 d	28.40 e	14.33 d	16.67 f
T <sub>2</sub>	35.00 i	24.67 f	23.33 i	10.36 f	24.67 b
T <sub>3</sub>	45.43 d	36.07 c	30.33 d	15.33 cd	14.67 g
T <sub>4</sub>	36.37 h	26.87 e	24.33 hi	10.77 f	22.67 c
T <sub>5</sub>	48.37 c	37.40 bc	31.73 c	16.57 bc	12.67 h
T <sub>6</sub>	38.40 g	27.67 e	25.33 gh	12.00 e	22.67 c
T <sub>7</sub>	50.33 b	38.47 b	34.37 b	18.27 b	10.67 i
T <sub>8</sub>	41.33 f	31.07 d	26.43 fg	12.33 e	20.67 d
T <sub>9</sub>	52.33 a	40.67 a	36.33 a	20.33 a	8.67 j
T <sub>10</sub>	43.00 e	31.70 d	27.33 ef	14.00 d	18.67 e
Lsd	1.25	2.19	1.31	0.74	1.32
SE	1.04	1.04	0.82	0.31	1.00

Data represents the mean of three replications; in a column, values having same letter (s) do not differ significantly at 5% level

#### Effect of different treatments on the growth and galling incidence of chilli inoculated with *Meloidogyne javanica* after 10 days of transplantation at 90 days of inoculation

The highest shoot length 67.33 cm was recorded with Bermuda grass (T<sub>9</sub>) leaf extract followed by Water spinach leaf (T<sub>7</sub>) extract having 65.33 cm (Table 3). Ivy leaf morning glory leaf (T<sub>5</sub>) extract treated plant gave comparatively higher shoot length 62.70 cm followed by Nisinda leaf (T<sub>3</sub>) extract having 59.67 cm. Higher but same type in shoot length was noted with Justicia leaf (T<sub>1</sub>) extract, Bermuda grass (T<sub>10</sub>) extract and Water spinach leaf (T<sub>8</sub>) extract having 57.73 cm, 57.00 cm and 56.33 cm, respectively. Ivy morning glory leaf (T<sub>6</sub>) extract was found with comparatively lower shoot length having 52.77 cm. Lower and identical response in shoot length was recorded with Nisinda leaf (T<sub>4</sub>) extract and Bermuda grass (T<sub>2</sub>) extract having 51.33 cm and 50.33 cm, respectively. The lowest 47.33 cm shoot length was found with the control (T<sub>0</sub>) treatment. In case of length of root, Bermuda grass (T<sub>9</sub>) leaf extract gave the highest root length 52.17 cm followed by Water spinach leaf (T<sub>7</sub>) extract having 49.33 cm (Table 3). Comparatively higher root length 46.33 cm was recorded with Ivy leaf morning glory leaf (T<sub>5</sub>) extract followed by Nisinda leaf (T<sub>3</sub>) extract having 44.67 cm. Justicia leaf (T<sub>1</sub>) extract, Bermuda grass (T<sub>10</sub>) extract and Water spinach leaf (T<sub>8</sub>) extract were recorded with higher but equal type root length having 41.67 cm, 41.33 cm and 41.00 cm, respectively. Comparatively lower root length 37.67 cm was recorded with Ivy leaf morning glory leaf (T<sub>6</sub>) extract followed by Nisinda leaf (T<sub>4</sub>) extract having 36.67 cm. Justicia leaf (T<sub>2</sub>) extract treated plant exhibited lower root length 34.67 cm. The control (T<sub>0</sub>) treatment was appeared with the lowest root length 31.33 cm. Bermuda grass (T<sub>9</sub>) treated plant gave the highest 48.37 g fresh shoot weight (Table 3). Comparatively higher 46.33 g fresh shoot weight was noted with Water spinach leaf (T<sub>7</sub>) extract. Ivy leaf morning glory leaf (T<sub>5</sub>) extract was noted with higher fresh shoot weight having 44.37 g followed by Nisinda leaf (T<sub>3</sub>) extract with 42.37 g. Lower and identical response in fresh shoot weight was noted with Justicia leaf (T<sub>1</sub>) extract, Bermuda grass (T<sub>10</sub>) extract, Water spinach leaf (T<sub>8</sub>) extract, Ivy morning glory leaf (T<sub>6</sub>) extract, Nisinda leaf (T<sub>4</sub>) extract and Justicia leaf (T<sub>2</sub>) extract having 40.32 g, 39.33 g, 38.37 g, 37.32 g, 36.33 g and 35.29 g, respectively. The lowest 32.37 g fresh shoot weight was found to give with the control (T<sub>0</sub>) treatment. The highest fresh root weight 30.33 g was recorded with Bermuda grass (T<sub>9</sub>) extract followed by Water spinach leaf (T<sub>7</sub>) extract having 28.00 g (Table 3). Ivy leaf morning glory leaf (T<sub>5</sub>) extract treated plant gave comparatively higher fresh root weight 26.17 g followed by Nisinda leaf (T<sub>3</sub>) extract having 24.33 g. Justicia leaf (T<sub>1</sub>) extract and Bermuda grass (T<sub>10</sub>) extract was noted with higher and identical response on fresh root weight having 22.33 g and 22.00 g, respectively. Lower but equal in root length was recorded with Water spinach leaf (T<sub>8</sub>) extract, Ivy leaf mornig glory leaf (T<sub>6</sub>) extract, Nisinda leaf (T<sub>4</sub>) extract and Justicia leaf (T<sub>2</sub>) extract having 20.67 g, 19.33 g, 18.67 g and 17.33 g, respectively; while the control (T<sub>0</sub>) treatment was found with the lowest 14.00 g root weight. With respect to galling, control (T<sub>0</sub>) treatment gave the highest 32.33

gall/g root followed by Justicia leaf (T<sub>2</sub>) extract having 28.33 gall/g root (Table 3). Nisinda leaf (T<sub>4</sub>) extract was recorded with comparatively higher number 26.33 gall/g root. Higher but similar effect on gall/g root was found with Ivy leaf morning glory leaf (T<sub>6</sub>) extract and Water spinach leaf (T<sub>8</sub>) extract having 24.33 and 24.00 gall/g root, respectively followed by Bermuda grass (T<sub>10</sub>) extract having 21.33 gall/g root. Justicia leaf (T<sub>1</sub>) extract treated plant gave comparatively lower number 19.67 gall/g root followed by Nisinda leaf (T<sub>3</sub>) extract having 17.67 gall/g root. Lower number 16.33 gall/g root was appeared with Ivy leaf morning glory leaf (T<sub>5</sub>) followed by Water spinach (T<sub>7</sub>) leaf extract having 14.33 gall/g root. The lowest 12.33 gall/g root was observed with control (T<sub>9</sub>) treatment.

Table 3. Effect of different treatments on the growth and galling incidence of inoculated Chilli with *Meloidogyne javanica* after 10 days of transplantation at 90 days of inoculation

Treatments	Length of shoot (cm)	Length of root (cm)	Fresh weight of shoot (g)	Fresh weight of root (g)	No. of gall / g root
T <sub>0</sub>	47.33 g	31.33 h	32.37 j	14.00 i	32.33 a
T <sub>1</sub>	57.73 e	41.67 e	40.32 e	22.33 e	19.67 f
T <sub>2</sub>	50.33 h	34.67 g	35.29 i	17.33 h	28.33 b
T <sub>3</sub>	59.67 d	44.67 d	42.37 d	24.33 d	17.67 g
T <sub>4</sub>	51.33 h	36.67 f	36.33 hi	18.67 gh	26.33 c
T <sub>5</sub>	62.70 c	46.33 c	44.37 c	26.17 c	16.33 h
T <sub>6</sub>	52.77 g	37.67 f	37.32 gh	19.33 fg	24.33 d
T <sub>7</sub>	65.33 b	49.33 b	46.33 b	28.00 b	14.33 i
T <sub>8</sub>	56.33 f	41.00 e	38.37 fg	20.67 f	24.00 d
T <sub>9</sub>	67.33 a	52.17 a	48.37 a	30.33 a	12.33 j
T <sub>10</sub>	57.00 ef	41.33 e	39.33 ef	22.00 e	21.33 e
LSD	1.47	1.48	1.36	0.65	1.26
SE	1.08	1.00	0.83	0.35	1.04

Data represents the mean of three replications; in a column, values having same letter (s) do not differ significantly at 5% level

#### Effect of different treatments on the development of adult female, J<sub>2</sub>, J<sub>3</sub>, and J<sub>4</sub> juveniles of *Meloidogyne javanica* after 10 days of transplantation at 90 days of inoculation

The highest 37.67 adult female/10 gall was recorded with non-treated control (T<sub>0</sub>) treatment followed by Justicia leaf (T<sub>2</sub>) extract having 32.67 adult female/10 gall (Table 7). Nisinda leaf (T<sub>4</sub>) extract was found with comparatively higher number 25.67 adult female/10 gall followed by Ivy morning glory leaf (T<sub>6</sub>) extract having 20.67 adult female/10 gall. Higher number but similar effect on adult female/10gall was recorded with Water spinach leaf (T<sub>8</sub>) extract and Bermuda grass (T<sub>10</sub>) extract having 18.67 and 17.67 adult female/10 gall, respectively. Justicia leaf (T<sub>1</sub>) extract and Nisinda leaf (T<sub>3</sub>) extract gave comparatively lower and identical response having 15.67 and 14.67 adult female /10 gall, respectively. Lower but similar effect on adult female/10 gall was recorded with Ivy leaf morning glory leaf (T<sub>5</sub>) extract and Water spinach leaf (T<sub>7</sub>) extract having 12.67 and 11.67, respectively, while Bermuda grass (T<sub>9</sub>) extract gave the lowest 8.67 adult female /10 gall. The control (T<sub>0</sub>) treatment was recorded with the highest 19.33 J<sub>2</sub> juvenile /10 gall followed by Justicia leaf (T<sub>2</sub>) extract having 17.33 J<sub>2</sub> juvenile /10 gall. Nisinda leaf (T<sub>4</sub>) extract was found with comparatively higher 15.33 J<sub>2</sub> juvenile / 10 gall followed by Ivy morning glory leaf (T<sub>6</sub>) extract having 13.33 J<sub>2</sub> juvenile /10 gall. Higher but similar effect on J<sub>2</sub> juvenile /10gall was recorded with Water spinach leaf (T<sub>8</sub>) extract and Bermuda grass (T<sub>10</sub>) extract having 11.33 and 10.33, respectively. Justicia leaf (T<sub>1</sub>) extract gave comparatively lower J<sub>2</sub> juvenile/10 gall having 8.33. Lower but similar effect on J<sub>2</sub> juvenile/10 gall was recorded with Nisinda leaf (T<sub>3</sub>) extract Ivy leaf morning glory leaf (T<sub>5</sub>) extract and Water spinach leaf (T<sub>7</sub>) extract having 6.33, 5.33 and 4.33 J<sub>2</sub> juvenile / 10 gall, respectively; while Bermuda grass (T<sub>9</sub>) extract exhibited the lowest 2.33 J<sub>2</sub> juvenile /10 gall juvenile (Table 4). The highest 24.67 J<sub>3</sub> juvenile /10 gall was recorded with non- treated control (T<sub>0</sub>) treatment followed by Justicia leaf (T<sub>2</sub>) extract with 22.67 J<sub>2</sub> juvenile/10 gall. Nisinda leaf (T<sub>4</sub>) extract was found with comparatively higher number 20.67 J<sub>3</sub> juvenile /10 gall followed by Ivy morning glory leaf (T<sub>6</sub>) extract having 18.67 J<sub>3</sub> juvenile / 10 gall. Higher J<sub>3</sub> juvenile / 10 gall was recorded with Water spinach leaf (T<sub>8</sub>) extract having 16.67 followed by Bermuda grass (T<sub>10</sub>) extract having 14.67. Justicia leaf (T<sub>1</sub>) extract, Nisinda leaf (T<sub>3</sub>) extract and Ivy leaf Morninglory leaf (T<sub>5</sub>) extract gave comparatively lower and identical response having 12.67, 11.67 and 11.67 J<sub>3</sub> juvenile /10 gall, respectively. Lower of J<sub>3</sub> Juvenile /10 gall was recorded with Water spinach leaf (T<sub>7</sub>) extract having 9.67 J<sub>3</sub> Juvenile / 10 gall, while Bermuda grass (T<sub>9</sub>) extract gave the lowest 7.67 J<sub>3</sub> juvenile / 10 gall (Table 4). The control (T<sub>0</sub>) treatment was noted with the highest 31.67 J<sub>4</sub> juvenile /10 gall followed by Justicia leaf (T<sub>2</sub>) extract having 28.67 J<sub>4</sub> juvenile/10 gall. Comparatively higher 26.67 J<sub>4</sub> juvenile /10 gall was recorded with Nisinda leaf (T<sub>4</sub>) extract. Higher and identical effect was observed with Ivy leaf morninglory leaf (T<sub>6</sub>) extract, Water spinach leaf (T<sub>8</sub>) extract and Bermuda grass (T<sub>10</sub>) having 23.67, 22.67 and 21.67 J<sub>4</sub> juvenile /10 gall, respectively. Comparatively lower 19.67 J<sub>4</sub> juvenile /10 gall was recorded with Justicia leaf (T<sub>1</sub>) extract followed by Nisinda leaf (T<sub>3</sub>) extract with 7.67 J<sub>4</sub>/10 gall. Ivy leaf morninglory leaf (T<sub>5</sub>) extract was found with

lower 15.67 J<sub>4</sub> /10 gall followed by Water spinach leaf (T<sub>7</sub>) extract having 13.67 J<sub>4</sub> juvenile /10 gall; while the lowest 11.67 J<sub>4</sub> juvenile /10 gall was recorded with Bermuda grass (T<sub>9</sub>) extract (Table 4).

Table 4. Effect of different treatments on the development of adult female, J<sub>2</sub>, J<sub>3</sub> and J<sub>4</sub> juveniles of *Meloidogyne javanica* after 10 days of transplantation at 90 days of inoculation

Treatments	No. of adult female/10 gall	No .of J <sub>2</sub> /10gall	No .of J <sub>3</sub> /10 gall	No .of J <sub>4</sub> /10gall
T <sub>0</sub>	37.67 a	19.33 a	24.67 a	31.67 a
T <sub>1</sub>	15.67 f	8.33 f	12.67 g	19.67 f
T <sub>2</sub>	32.67 b	17.33 b	22.67 b	28.67 b
T <sub>3</sub>	14.67 f	6.33 g	11.67 g	17.67 g
T <sub>4</sub>	25.67 c	15.33 c	20.67 c	26.67 c
T <sub>5</sub>	12.67 g	5.33 gh	11.67 g	15.67 h
T <sub>6</sub>	20.67 d	13.33 d	18.67 d	23.67 d
T <sub>7</sub>	11.67 g	4.33 h	9.67 h	13.67 i
T <sub>8</sub>	18.67 e	11.33 e	16.67 e	22.67 de
T <sub>9</sub>	8.67 h	2.33 i	7.67 i	11.67 j
T <sub>10</sub>	17.67 e	10.33 e	14.67 f	21.67 e
LSD	1.65	1.32	1.33	1.33
SE	1.52	0.94	0.94	1.06

Data represents the mean of three replications; in a column values having same letter (s) do not differ significantly at 5% level

## DISCUSSION

Pot experiments with 11 treatments using Bermuda grass (S and S/2) extract, Water spinach leaf (S and S/2) extract, Ivy leaf morning glory leaf (S and S/2) extract, Nisinda leaf (S and S/2) extract and Justicia leaf (S and S/2) extract including control (T<sub>0</sub>) were evaluated against root-knot (*Meloidogyne javanica*) of chilli after 10 days of transplantation. Higher values of the treated plants in relation to shoot and root length as well as shoot and root weight were recorded with the indication of better response of the treatments. Similarly, the lower values of gall number adult female, J<sub>2</sub>, J<sub>3</sub> and J<sub>4</sub> juvenile stages of the nematode in the treated plants indicated their better effect.

The biological control of root-knot disease caused by *Meloidogyne* spp. with plant products had been practiced by many authors. On decomposition of the plant products like leaves in the soil toxic substances are released which are directly lethal or harmful to the soil nematodes. Khan *et al.* (2001) reported about the nematicidal effect of neem V<sub>12</sub>, Nimbidin and thionimone which were found highly effective in killing the nematodes and inhibiting the larval hatch of *Meloidogyne incognita*. Alam (1990) reported that Neem (*Azadirachta indica*) had nematicidal properties. In the present study, treatment with Bermuda grass extract was found to give superior response by giving highest shoot and root length, fresh weight of shoot and root corresponding lowest galling incidence in chilli plant. Moreover, the population of adult female and different juvenile stages of *Meloidogyne javanica* was also reduced to a great extent with Bermuda grass extract. Similar observations in increased growth of plants and reduction in nemic population with Neem and its products were also reported by Hussain (1984), Lee (1987), Akhtar and Alam (1993) and Muktar *et al.* (1994). Naik *et al.* (1998) also reported that extract of Neem (*Azadirachta indica*) products had no adverse effects on the growth of tomato plants, but significantly decreased the nematode development and reproduction. In general, maximum reduction in gall, eggmass and production were recorded in nematicidal treated plants compared with seed extract and oil cake.

In the pot experiment, standard (S) of Water spinach leaf extract suppressed the activity of *Meloidogyne javanica* with comparatively lower galling incidence and corresponding comparatively higher significant shoot and root length as well as fresh weight of shoot and root of chilli. Similarly standard (S) leaf extract of Ivy leaf morning glory, Nisinda, and Justicia and half- standard (S/2) of Bermuda grass was very effective against *Meloidogyne javanica* to reduce the number of galling incidence and increased shoot and root length; shoot and root weight along with the lower number of developing J<sub>4</sub>, J<sub>3</sub>, J<sub>2</sub> juvenile and adult female in treated plant. All these reports are in consonance with the present findings. Ahmad and Karim (1991) reported that standard (S) and half standard (S/2) solution of Dholkalmi (*Ipomoea fistulosa*) suppressed the activity of *Meloidogyne javanica* with significant lower galling incidence and corresponding higher significant shoot and root length, fresh weight of shoot and root of brinjal. Ahmad *et al.* (1990) also observed that plant extracts of (*Ipomoea fistulosa*) were toxic to *Meloidogyne javanica* and it juvenile mortality. Standard concentration caused 100% mortality within 12h. In the present investigation half-standard (S/2) leaf extract of Water spinach, Ivy leaf morning glory, Nisinda and Justicia was found to give lower effect in respect of plant growth characters with lower length of shoot and root, fresh weight of shoot and root consequently with higher galling incidence and development of the nematode compared to the standard plant extracts.

Akhtar and Mahmood (1996) Reported that “Nimin” an industrial product containing neem triterpene, and oil from castor (*Ricinus communis*), mustard (*Brassica juncea*), neem (*Azadirachta indica*) and rocket-lettuce

(*Eruca sativa*) significantly suppressed populations of some ecto-parasitic nematodes and reduced the increase of *Meloidogyne incognita* of chilli (*Capsicum annuum*) cv. "Jawal" when applied as bare-root dips at concentrations of S, S/2 and S/10 (Standard solution 'S' prepared by using 10 ml of extract in 90 ml of distilled water) in pot experiments, Nimin gave the best result in terms of reduced root-knot incidence and improved plant growth, followed by oils of neem, castor rocket-lettuce and mustard. The effect of treatments was related to their concentrations. Islam (1995) tested the bittergourd (*Momordica charantia*) fruit extract and powder prepared from seeds against the root-knot (*Meloidogyne javanica*) disease of cucumber (*Cucumis sativus*) in glasshouse. Of four different treatments including control, treatment T<sub>2</sub> with concentration 'S' (standard) of bittergourd extract suppressed the activity of *Meloidogyne javanica* with significantly lowest galling incidence of cucumber. Significantly highest length of shoot and root and fresh weight of shoot and root with corresponding lowest galling incidence were recorded with this concentration in all the tests. Comparatively, better and identical growth responses of plant with corresponding lower galling incidence were observed with concentration S/2 of bitter gourd fruit extract and its seed powder are in agreement with the present finding. Better efficacy of the treatments (either standard or half-standard) resulted better growth of the chilli in respect to length of shoot and root, fresh weight of shoot and root. It also caused lower number of gall, adult female, J<sub>4</sub>, J<sub>3</sub> and J<sub>2</sub> juvenile when inoculated with *M. javanica* after 10 days of transplantation.

From the overall study, it was revealed that the highest plant growth character of chilli in respect of length of shoot and root, fresh weight of shoot and root and reduced incidence of galling with the lowest number of adult female, J<sub>2</sub>, J<sub>3</sub> and J<sub>4</sub> juveniles of *Meloidogyne javanica* were obtained with standard(S) Bermuda grass extract. Standard (S) leaf extract of Water spinach, Ivy morning glory and Nisinda gave comparatively better response in plant growth characters and reduced galling incidence and lower population of the nematode. Standard (S) leaf extract of Justicia and half-standard (S/2) of Bermuda grass extract gave better plant growth with lower galling incidence, while half standard (S/2) leaf extract of Water spinach, Ivy leaf morning glory, Nisinda and Justicia had more or less good effect with respect to length of shoot and root, fresh weight of shoot and root and reduced galling incidence as well as nematode population.

## CONCLUSION

The result of the present study revealed that the use of plant extracts, especially the extracts of Bermuda grass can be used as a means of biological control of *Meloidogyne javanica* in chilli. The findings, hopefully, be useful to the researchers in this discipline to explore the use of Bermuda grass extract include in other plant extract in nematode disease management of vegetables and spice crops economically and with eco-friendly condition. But more research need to be carried out in order to recommend the use of Bermuda grass extract, Water spinach leaf extract, Ivy leaf morning glory leaf extract, Nisinda leaf extract and Justicia leaf extract for controlling nematode of chilli at field level.

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