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Evaluation of Botanicals for the Management of Root-Knot Nematode, *Meloidogyne incognita* on Brinjal (*Solanum melongena* L.)

Vikas Kumar Aloria[1*], M.K. Sharma[2], Vishnu Dadhich[1], Rameshwar Lal[1] and Mukesh Jaiman[1]

[1]M.Sc. Scholar, Department of Nematology, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan), India.

[2]Professor, Department of Nematology, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan), India.

(Corresponding author: Vikas Kumar Aloria)*

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ABSTRACT: Brinjal (Solanum melongena) crop output is significantly affected by root-knot nematodes, particularly *Meloidogyne incognita*. Root-galls of brinjal produced by *Meloidogyne incognita* can be efficiently suppressed by applying botanicals, which boosts yield and plant growth. Experimental was carried out of evaluation of botanicals for the management of root-knot nematode, *Meloidogyne incognita* (Kofoid and White 1919) Chitwood, 1949 on Brinjal, efficacy of botanicals *viz.*, Tulsi, Pyrethrum, Datura, Ashwagandha and Congress grass were added to soil each @ 2.5 and 5 gm per kg soil. Plants were harvested after 60 days of transplanting and the observations on plant growth characters *viz.*, shoot length, shoot weight, root length, root weight and nematode reproduction *viz.*, No. of galls/ plant, No. of egg masses/plant, No. of egg and larvae/ egg mass, nematode juvenile/ 200 cc soil and total nematode population in soil were recorded. Soil application of Datura @ 5 gm/kg soil was found superior treatment, whereas shoot length (41.90 cm), shoot weight (31.40gm), root length (32.70cm), root weight (3.85gm) and nematode reproduction *viz.*, No. of galls/ plant (19.00), No. of egg masses/plant (13.00), No. of egg and larvae/ egg mass (75.00), nematode juvenile/ 200 cc soil (289.00) and total nematode population in soil (3865.00), respectively, followed by Pyrethrum @ 5 gm/kg soil and Congress grass @ 5 gm/kg soil in improving plant growth of brinjal and reducing reproduction of root knot nematode.

Keywords: Management, Root-knot Nematode, Botanicals and Brinjal.

INTRODUCTION

Brinjal (*Solanum melongena* L.) is also known as eggplant, belongs to the family *Solanaceae*, is native of India, (John, 2011). It is an important vegetable crop grown throughout the world, especially in South Asia. It is also known by different names in local language like begun (Bengali), ringna (Gujarathi), baingan (Hindi), badane (Kannada), waangum (Kashmiri), vange (Marathi), baigan (Oriya), vashuthana (Malayalam), kathiri (Tamil), venkaya (Telugu) and peethabhala (Sanskrit). Brinjal is a warm season crop, therefore susceptible to severe frost. Low temperature during the cool season causes deformation of fruits.

Brinjal can be grown practically in all soils from light sandy to heavy clay loam soils, while clay loam and silt loam are well suited for higher yield. The soil should be deep, fertile and well drained. The soil pH should not be more than 5.5-6.0 for its better growth and development. Fruits are moderate sources of vitamins and minerals like phosphorous, calcium, iron and nutritive value varies from variety to variety. It has high nutritional values containing 92.7 % moisture, 1.4 g protein, 0.3 g fat, 0.3 g minerals, 13 g fibers, 40 g carbohydrates, 1241 international unit vitamin A, and 12 mg vitamin C /100 gm of edible portion (Choudhary, 1983).

The sedentary endo-parasite like the root knot nematodes (*Meloidogyne* species) is economically and scientifically important due to their wide hosting range, adaptability and high rate of reproduction (Luc, Sikora & Bridge, 2005). The four most destructive species in this genus are *M. javanica*, *M. arenenia*, *M. hapla* and *M. incognita*. The *M. incognita*, a single female lays about 500 to 5000 eggs in her life time (Ali *et al.*, 2013).

In India, *M. incognita* reported to cause 21% yield losses in Brinjal, (*Solanum melongena*) (Gawade *et al.*, 2022). The loss of Indian agriculture is estimated to about Rs. 210 crore annually (Jain *et al.*, 2007). Estimated overall average annual yield losses of the world's major vegetable crops by nematodes are 12.3 per cent. Average losses for the 40 crops in developed countries were estimated to be 8.8 per cent compared with 14.6 per cent for developing countries. (Plant Nematology N.G. Ravichndra, 392 pp). Losses caused by root-knot nematode, *M. incognita* were estimated to be 33.68 per cent in brinjal (Reddy and Singh 1981). Crop losses from root-knot nematodes cost the global

economy more than $100 billion each year (Ralmi *et al*., 2016).

Meloidogyne incognita alone infecting about 250 and *Meloidogyne javanica* infecting about 150 genera of plants (Krishnappa, 1985). Therefore *Meloidogyne incognita* is economically most important than other species of vegetable crops. Globally, a frequency estimate of sample from 75 countries showed that *M. incognita* most widespread with 53 per cent occurrence (Johnson and Fassuliotis 1984), *M. javanica* 50 per cent, *M. hapla* 8 per cent, *M. areneria* 8 per cent and other spp. 2 per cent.

Synthetic nematicides were the most effective and immediate control tool, they were reported to be hazardous to human health, environmental plants and animals, as well as agriculturally important soil flora and fauna, and they were quite expensive (Guan *et al*., 2014; Nicolopoulou-Stamati *et al*., 2016; Navarrete *et al*., 2018; Alfy *et al*., 2020;). This, combined with rising demand for organically grown foods, sparked a search for alternative pest management approaches and botanical pesticides as more appealing alternatives to chemical pesticides as well as safer and equally effective to chemically synthesized counterparts (Isman, 2006).

Botanicals are environmentally friendly and safe for farmers uses. Several botanicals are known to possess nematicidal components, which may be utilized as organic amendments or bio-pesticides. Plant extracts are very effective, cheap, easily applied and eco-friendly for the management of plant parasitic nematode (Chitwood, 2002; Chitwood, 2003, Adekunle and Fawole 2003, Fawole, 2009). Consequently, the extracts either enabled the plants to resist the nematode invasion or activated directly the defence mechanisms of the plants and enhanced growth (Hussain *et al.,* 2011).

MATERIALSANDMETHODS

Experimental site. The experiment was conducted in cage house at Rajasthan College of Agricultutre, Department of Nematology, Udaipur. The region falls under agro-climatic zone IV-A Semi-humid Southern Plains or The Aravali Hills of Rajasthan.

Disinfection and Filling of pots. Earthen pots were washed, cleaned and disinfected before use by rinsing them with 4 per cent formalin solution. The formalin was allowed to evaporate before their use for experimentation. In all the experiments earthen clay pots were taken and filled with 1 kg infested soil. Selection of pots was made in such a way that all the pots were of almost same size, volume and should have a hole at the bottom, which was covered with a piece of broken clay pots before filling the soil. Each pot, filled with equal quantity of soil. Some space from the above was left unfilled for watering.

Preparation and maintenance of pure culture of *M. incognita*. Egg masses were observed and carefully detached from roots, under a stereoscopic binocular microscope, with the help of teasing needle and a pair of forceps further the roots were teased to take out adult female nematodes carrying egg-masses. These egg masses were then surface sterilized with 0.1% sodium hypochlorite for 10 seconds followed by five washings with sterile water. Later, these females were stained in 0.1% acid fuchsin in lactophenol at 80°C and cleared in pure lactophenol (McBeth *et al*., 1941). Posterior cuticular (perineal) patterns of adult females were cut with the help of a scalpel and the body contents were removed with pigeon hairbrush no. 1 (Taylor and Netscher 1974) and mounted on glass slides. Observations of such patterns were made under a high-power compound microscope, critical comparison of several such patterns revealed the presence of *M. incognita* species.

Egg masses, collected from the infected roots were kept in distilled water in watch glasses at room temperature for hatching. Freshly hatched J_2 were inoculated on 15 days old brinjal plants already grown and maintained in earthen clay pots filled with steam sterilized soil to obtained adequate pure population of *M. incognita* on the plants and in soil to carry out further experiments.

Raising of Nursery and transplanting. Brinjal variety selection-3 was used in all experiments. Brinjal seedlings were raised in the pot trays. 4-5 weeks old seedlings used for transplanting in pot for various experiments. Uniform sized brinjal seedlings were transplanted in pots. One healthy plant in each pot and others were uprooted carefully without disturbing the one to be maintained.

After care and harvest. Care was taken right from transplanting to till harvest of experiments. The observations on enzyme analysis were taken after 14 and 28 days of transplanting. Observation for enzyme analysis and various growth parameters *viz*., fresh root and shoot weight, shoot and root length were recorded without delay whereas for studying nematode infestation, the plant tissues were stained in 0.1% acid fuchsin in lacto phenol at 80ºC for 2-3 minutes (McBeth *et al*., 1941). Then after gentle wash, roots were kept in clear lacto phenol for 24 hrs and then examined under stereoscopic binocular microscope for nematode infection and observation of number of galls/plants, number of egg masses/plant and number of eggs/egg mass were recorded. Nematode population/200 cc soil and final nematode population were also calculated.

EXPERIMENTWISE METHODOLOGY

Management of root-knot nematode on brinjal using botanicals. The Leaf powder of Tulsi leaves, Pyrethrum leaves, Datura leaves, Ashwagandha and Congress grass leaves were added to soil each @ 2.5 and 5 gm per kg soil. Each treatment was replicated three times. Untreated check was also maintained for comparison. Plants were harvested after 60 days of transplanting and the observations on plant growth characters and nematode reproduction were recorded. Utmost care was taken right from sowing to till harvest of experiment for proper growth and development of plants.

Observation to be recorded. Shoot length (cm), Shoot weight (gm), Root weight (gm), Root length (cm),Number of galls/ plant, Number of egg

masses/plant, Number of eggs and larvae /egg mass, Nematode juvenile/200cc soil, Total Nematode population in soil

RESULT AND DISCUSSION

Plant growth characters

Shoot length (cm). Botanicals applied showed that higher doses of botanicals *i.e.* 5.0 gm/ kg soil were found more effective than lower doses i.e. 2.5 gm/ kg of soil. The significant higher increase in shoot length was observed with Datura @ 5 gm/kg soil (41.90 cm) followed by Pyrethrum @ 5 gm/kg soil (38.50 cm) and Congress grass @ 5 gm/kg soil (37.80 cm). While minimum shoot length (23.10 cm) was recorded with untreated check.

Shoot weight (g). Data revealed that all the botanicals applied increased the shoot weight significantly as compared to untreated check. Result also showed that higher doses of botanicals i.e. 5.0 gm/ kg soil were found more effective than lower doses i.e. 2.5 gm/ kg of soil. The significant increase in shoot weight was observed with Datura @ 5 gm/kg soil (31.40 gm) followed by Pyrethrum @ 5 gm/kg soil (29.00 gm) and Congress grass @ 5 gm/kg soil (28.70 gm). However, the minimum shoot weight (12.20 gm) was recorded under control.

Root length (cm). Data (Table 1) revealed that among botanicals applied increased the root length significantly as compared to control. The significant higher increase in root length was observed with Datura @ 5 gm/kg soil (32.70 cm) followed by Pyrethrum @ 5 gm/kg soil (31.10 cm) and Congress grass @ 5 gm/kg soil (29.30 cm). While, minimum root length (15.10 cm) was recorded over control.

Root weight (g). Data revealed that all the botanicals applied increased the root weight significantly as compared to untreated check. Result also showed that higher doses of botanicals i.e. 5.0 gm/ kg soil were found more effective than lower doses i.e. 2.5 gm/ kg of soil. The significant increase in root weight was observed with Datura @ 5 gm/kg soil (3.85 gm) followed by Pyrethrum @ 5 gm/kg soil (3.50 gm) and Congress grass @ 5 gm/kg soil (3.30 gm). While, minimum root weight (1.70 gm) was recorded with untreated check.

Nematode Reproduction:

Number of galls/ plant. Data showed that all the botanicals applied decrease the number of galls/ plant significantly as compared to untreated check. Result also showed that higher doses of botanicals i.e. 5.0 gm/ kg soil were found higher effective than lower doses i.e. 2.5 gm/ kg of soil. The significant higher decrease in number of galls per plant was observed with Datura @ 5 gm/kg soil (19.00) followed by Pyrethrum @ 5 gm/kg soil (23.00) and Congress grass @ 5 gm/kg soil (24.30). However, the maximum numbers of galls per plant (48.00) were recorded under control.

Number of egg masses per plant. Data revealed (Table 1) that all the botanicals applied decrease the number of egg masses significantly as compared to untreated check. Result also showed that more doses of botanicals i.e. 5.0 gm/ kg soil were found highly effective than lower doses i.e. 2.5 gm/ kg of soil. The significant higher decrease in number of egg masses was observed with Datura @ 5 gm/kg soil (13.00) followed by Pyrethrum @ 5 gm/kg soil (15.00) and Congress grass @ 5 gm/kg soil (16.00). However, maximum numbers of egg masses (37.00) were recorded under control.

Number of eggs and larvae per egg mass. Data revealed (Table 1) that all the botanicals applied decrease the eggs and larvae significantly as compared to untreated check. Result also showed that higher doses of botanicals i.e. 5.0 gm/ kg soil were found more effective than lower doses i.e. 2.5 gm/ kg of soil. The significant decrease in eggs and larvae was observed with Datura @ 5 gm/kg soil (75.00) followed by Pyrethrum @ 5 gm/kg soil (85.14) and Congress grass @ 5 gm/kg soil (94.00). While, maximum eggs and larvae (214.00) were recorded under control.

Nematode juvenile/200cc soil. Data showed that all the botanicals applied decrease the juvenile population significantly as compared to untreated check. Result also showed that higher doses of botanicals i.e. 5.0 gm/ kg soil was found highly effective than lower doses i.e. 2.5 gm/ kg of soil. The significantly decrease in juvenile population was observed with Datura @ 5 gm/kg soil (289.00) followed by Pyrethrum @ 5 gm/kg soil (324.00) and Congress grass @ 5 gm/kg soil (365.00). While, maximum larval population (1016.00) was recorded under control.

Total nematode population in soil. Data showed that among the botanicals applied decrease the total nematode population in soil significantly as compared to control. Result also showed that higher doses of botanicals i.e. 5.0 gm/ kg soil were found highly effective than lower doses i.e. 2.5 gm/ kg of soil. The decrease nematode population was observed with Datura @ 5 gm/kg soil (3865.00) followed by Pyrethrum @ 5 gm/kg soil (4517.10) and Congress grass @ 5 gm/kg soil (5154). While, maximum nematode population (18078.00) was recorded under control.

Plate 1: Effect of botanicals on plant growth and nematode reproduction in pot condition.

Table 1: Effect of soil treatments of root-knot nematode, *M. incognita* on brinjal by using botanicals.

Botanicals	Shoot length (cm)	Shoot weight (gm)	Root length (cm)	Root weight (gm)	Number of galls/ plant	Number of egg masses/ plant.	Number of eggs and larvae/ egg mass	Nematode juvenile/200cc soil	Total nematode population in soil
Soil Application of Tulsi (*Ocimum tenuiflorum*) @ 2.5 gm/kg soil	28.00	20.90	19.00	2.15	37.00	24.00	137.00	638.00	9668.00
	(21.21)	(71.31)	(25.83)	(26.47)	(22.92)	(35.14)	(35.98)	(37.20)	(46.52)
Soil Application of Tulsi (*Ocimum tenuiflorum*) @ 5 gm/kg soil	31.60	22.50	22.80	2.45	32.00	19.00	107.00	599.00	8237.00
	(36.80)	(84.43)	(50.99)	(44.12)	(33.33)	(48.65)	(50.00)	(41.04)	(54.44)
Soil Application of Pyrethrum (*Chrysanthemum cinerarieaefolium*) @ 2.5 gm/kg soil	35.40	25.00	25.70	3.10	28.00	18.00	106.00	441.00	6318.00
	(53.25)	(104.92)	(70.20)	(82.35)	(41.67)	(51.35)	(50.47)	(56.59)	(65.05)
Soil Application of Pyrethrum (*Chrysanthemum cinerarieaefolium*) @ 5 gm/kg soil	38.50	29.00	31.10	3.50	23.00	15.00	85.14	324.00	4517.10
	(66.67)	(137.70)	(105.96)	(105.88)	(52.08)	(59.46)	(60.21)	(68.11)	(75.01)
Soil Application of Datura (*Datura stramonium*) @ 2.5 gm/kg soil	35.70	27.05	27.90	3.20	24.60	17.00	97.00	402.00	5669.00
	(54.55)	(121.72)	(84.77)	(88.24)	(48.75)	(54.05)	(54.67)	(60.43)	(68.64)
Soil Application of Datura (*Datura stramonium*) @ 5 gm/kg soil	41.90	31.40	32.70	3.85	19.00	13.00	75.00	289.00	3865.00
	(81.39)	(157.38)	(116.56)	(126.47)	(60.42)	(64.86)	(64.95)	(71.56)	(78.62)
Soil Application of Ashwagandha (*Withania sominifera*) @ 2.5 gm/kg soil	31.10	20.30	21.00	2.35	34.00	23.00	125.00	558.00	8455.00
	(34.63)	(66.39)	(39.07)	(38.24)	(29.17)	(37.83)	(41.59)	(45.08)	(53.23)
Soil Application of Ashwagandha (*Withania sominifera*) @ 5 gm/kg soil	33.85	23.85	23.60	2.80	29.00	19.00	103.00	435.00	6307.00
	(46.54)	(95.49)	(56.29)	(64.71)	(39.58)	(48.65)	(51.87)	(57.18)	(65.11)
Soil Application of Congress grass (*Parthenium hysterophorus*) @ 2.5 gm/kg soil	33.50	22.00	24.20	2.85	31.70	22.00	119.00	480.00	7418.00
	(45.02)	(80.33)	(60.26)	(67.65)	(33.96)	(40.54)	(44.39)	(52.76)	(58.97)
Soil Application of Congress grass (*Parthenium hysterophorus*) @ 5 gm/kg soil	37.80	28.70	29.30	3.30	24.30	16.00	94.00	365.00	5154.00
	(63.64)	(135.25)	(94.04)	(94.12)	(49.38)	(56.76)	(56.07)	(64.07)	(71.49)
Control	23.10	12.20	15.10	1.70	48.00	37.00	214.00	1016.00	18078.00
SEm±	1.28	0.91	0.91	0.11	1.43	0.75	3.51	12.77	109.59
CD (P=0.05)	3.76	2.66	2.67	0.31	4.19	2.21	10.32	37.54	322.26

: [(Data are the avg. value of four replications), (Initial inoculation level: 2 larvae/g soil), {Values in parentheses are % increase (Plant Growth Characters), decrease (Nematode Reproduction) over check}].

DISCUSSION

Leaf powder of botanicals Tulsi, Pyrethrum, Datura, Ashwagandha and Congress grass were used as soil application @2.5gm and 5.0gm/kg soil of each in order to find out the suitable dose for the management of root-knot nematode infecting Brinjal. Data showed that different botanicals were significantly effective in improving the plant growth characters to a varied

degree and in reducing the nematode reproduction over the untreated check. Improvement in plant growth characters and reduction of nematode reproduction were directly proportionate to applied doses of botanicals. However, among these botanicals, Datura was found the most effective as compared to Pyrethrum, Congress grass in improving plant growth characters and reduction of nematode reproduction.

Among doses, Datura@5gm/kg soil found superior over Datura@2.5gm/kg soil. Further it has also been reported that among botanicals and dose interactions, Datura @ 5 gm/kg soil and Pyrethrum, @ 5 gm/kg soil in improving plant growth characters(shoot length and weight, root length and weight) and suppressing the nematode reproduction (Number of galls per plant, Number of egg masses per plant, Number of eggs & larvae per egg mass, final nematode population per 200cc soil and total nematode population).

In the present investigation among dose, 5.0 gm/kg soil for each botanicals was found most effective in reducing nematode reproduction over 2.5gm/kg soil. This investigation is in adjustable conformity with the finding of Khan *et al*. (2004) tested the influence of amendments of datura (*Datura stramonium*), aak (*Calotropis procera*), neem (*Azadirachta indica*) leaves and sawdust of shisham (*Dalbergia sisso*) alone and in combination was investigated on population of *Meloidogyne incognita* in pot experiment. Significant increases were recorded in plant height, shoot weights and reduced numbers of galls. Hussain *et al.* (2011) studied that the use of antagonistic plants for the control of nematodes is a very attractive alternative. In the present study, nematicidal efficacy of four medicinal plants *viz. Azadirachta indica*, *Calotropis procera*, *Datura stramonium* and *Tagetes erecta* was ascertained for the control of *M. incognita*. All leaf amendments at different dosages significantly improved the plant growth characteristics and reduced root-knot infections compared with the untreated control.

Parihar *et al*. (2012) studied to evaluate, the antagonistic effect of organic additives against root-knot nematode infecting bottle gourd, under glass house conditions. Soil treated with Datura(100g) leaves were found most effective in reducing the reproductive potential of populations of root-knot nematode and increased chlorophyll content and plant growth parameters *viz.*, length, fresh and dry weight of shoot and root as compared to other plant species *viz., Argemone mexicana*, *Lantana camara*, *Parthenium hysterophorus* and *Withania somnifera*. Singh and Devi (2012) observed that the number of knots (root-knot index), shoot length, fresh shoot weight, root length and fresh root weight of the plant. All the treatments increased the plant growth parameters and reduced the incidence of root-knot nematode as compared to control. However, maximum reduction was obtained in Saijan followed by Marigold, Ashwagandha and Datura.

CONCLUSIONS

Results of soil application trial with leaves powder of Datura (*Datura stramonium*) @ 5 gm/kg soil, Pyrethrum (*Chrysanthemum cinerarieaefolium*) @ 5 gm/kg soiland Congress grass (*Parthenium hysterophorus*) @ 5 gm/kg soilwere effective for improving the growth of brinjal and reducing infection and reproduction of root knot nematode, *Meloidogyne incognita.* The effect of botanicals in brinjal crop infested with root-knot nematode, *M. incognita*. Results showed that application of datura was found to be the best treatment to enhance plant growth characters and minimum nematode reproduction @ 5gm/kg soil.

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Conflict of Interest. None.

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