IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 9, Issue 12 Ver. II (Dec. 2016), PP 07-12
www.iosrjournals.org

Management of Root-Knot Nematode (*Meloidogyne incognita*) Through Bare Root-Dip Treatment of Botanicals and Chemicals on Tomato (*Lycopersicon esculentum* Mill)

H.R. Gurjar, M.K. Sharma, Devprakash Gocher, S. Bhargava and A.S. Srivastva
Department of Nematology, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology Udaipur-313 001, Rajasthan, India.

Abstract: *The experiment was conducted at farmer's field during 2014 and 2015. Tomato seedlings raised in naturally infested nursery. Seedlings were lifted after 45 days of sowing and root-dip treatments were given by different plant extracts viz., Neem (Azadirachta indica), Jatropha (Jatropha curcas) and Aak (Calotropis gigantea) of 20 and 30 per cent concentrations and chemical viz., Imidacloprid of 2 and 3 per cent concentration exposure period was 4 hours. 30 % botanical extract of Neem (A. indica) and 3 % Imidacloprid was found effective. Reduced final nematode population (14183, 13072 and 13628) and increased tomato yield (237.50, 251.04 and 244.27 q/ha) in rest of the treatments in 2014, 2015 and pooled as compared to control. Individually Neem (A. indica) botanical extract was better over other botanicals dip to register lowest RKI at harvest (3.20, 3.01 and 3.10), reduced final nematode population (14163, 11852 and 13008) and yield was recorded maximum (237.50, 250.00 and 243.75 q/ha). Whereas Imidacloprid was found superior as compared to botanicals dip to register lowest RKI at harvest (2.32, 2.35 and 2.33), reduced final nematode population (6813, 7431 and 7122) and yield was maximum (285.42, 289.58 and 287.50 q/ha) in 2014, 2015 and pooled of both years.*

Keywords: *Botanicals and Chemicals, Meloidogyne incognita, Root-dip treatment, Tomato.*

I. Introduction

Tomato (*Lycopersicon esculentum* Mill) is an important crop grown throughout the world. Genus *Lycopersicon* has several species, but only two of them are edible i.e. *L. esculentum* Mill the cultivated tomato and *L. pimpinellifolium* Muller, small fruited tomato. A large number of tomato (*L. esculentum*) varieties are available in India and most of them have gained popularity and come under commercial cultivation. Fruits and vegetables constitute an important part of our dietary menu providing minerals and vitamins for necessary growth and development of the body. The tomato is an important vegetable crop which is cultivated throughout the year. In India, tomato is cultivated in 1204 thousand ha with a total production of 19402 thousand tonnes with the productivity 16.1 tonnes /ha (NHB, 2013-14). The total area under tomato cultivation in Rajasthan is 17.15 thousand ha with a total production of 81.75 thousand tonnes and the productivity is 4.76 tonnes /ha (Commissionerate of Horticulture, DOA, GOR, 2013-14).

The ability of this crop to grow throughout the year, except in extreme climatic conditions, makes it a very valuable to the growers and is an additional source of earning profit even during off season and tomatoes are being cultivated as food (Boswell, 1949). Tomatoes are used as a vegetable as well as an addition in almost all vegetable preparation and used for soup, salad, pickles, ketchup, sauce and in many other ways. It is the most important "Protective food" because of its special nutritive value and also of its widespread production.

In spite of development of various plant protection measures, the crop of such an economic importance, unfortunately suffers severely from several diseases caused by bacteria, fungi, viruses, nematodes or by adverse environmental conditions. Among nematodes, root-knot nematode, *Meloidogyne incognita* (Alam *et al*., 1975; Khan *et al*., 1978) *M. Javanica* (Rao and Prasad, 1969), reniform nematode, *Rotylenchulus reniformis* (Rao and Prasad, 1969; Kheir and Osman, 1977), lesion nematode, *Pratylenchus penetrans* (Estores, 1971) stunt nematode, *Tylenchorhynchus brassicae* (Alam *et al.*, 1975) attack on tomato crop but the root-knot nematode is the most common. It has received a greater attention in India and other countries though their first record seems to be in the last century (Barber, 1901). However, in Rajasthan, it was first noticed by (Arya, 1957) found its infestation on tomato and later (Yadav and Naik, 1966) found *Meloidogyne* spp. widely distributed in the soils of Udaipur, infecting vegetables and many other economically important crops.

During the last decade, incidence of root-knot nematode has been reported to be increasing in the various part of world including India. This increase may be due to intensive agriculture to maximize the production of field as well as vegetable crops. The success in increasing their population and survival may also probably due to their polyphagous nature, enabling them to survive and remain active throughout the year. Root-knot nematode cause severe losses in the tomato. Bhatti and Jain (1977) estimated the crop losses up to 46 per

cent in Haryana state. Reddy (1985) estimated per cent loss of (39.77) at 20 larvae/g soil in tomato field of Karnataka. Sharma and Baheti (1992) estimated losses up to 46 per cent against *M. incognita* on tomato. Sen (1960) had reported a loss of about 70 per cent to tomato, chilli, brinjal and okra from Bihar, due to this nematode. Estimated overall average annual yield losses of the world major vegetable crops by nematodes are 12.3 per cent an average loss for the 40 crops in developed countries were estimated to be 8.8 per cent compared with 14.6 per cent for developing countries (Ravichandra, 2008).

Looking to the economic importance and upcoming threat from plant parasitic nematodes (PPN's) especially the root-knot nematode, *Meloidogyne incognita,* the present study was undertaken to find out the effect of different chemicals and botanicals in relation to methods of treatment against root-knot nematode.

II. Materials And Methods

Preparation of Plant Extracts:

Healthy leaves of Neem (*Azadirachta indica*), Aak (*Calotropis gigantea*) and Jatropha (*Jatropha curcas*) were collected from herbal park of Rajasthan College Agriculture, Udaipur, Rajasthan. The collected plant parts were washed with sterile distilled water. One hundred grams of clean fresh plant materials were grind with 100 ml absolute alcohol. The mixture was allowed to stand for 48 hrs at room temperature and was subsequently filtered through filter paper (Rathi *et al*., 2006). The solvent was completely evaporated from the extract at 70 ºC till it became a semi-solid material (Handa *et a*l., 2008). These semi solid materials became stock solution by adding distilled water and different concentrations of each plant extracts were prepared for experimentation.

After 45 days infested seedlings of tomato variety "Dev" were uprooted from naturally infested nursery beds at farmer's field and dipped in following plant extracts and chemical treatments *viz*., T_{1-} Neem extract @ 20 % Concentration, T_{2-} Neem extract @ 30 % Conc., T_{3-} Jatropha extract @ 20 % Conc., T_{4-} Jatropha extract @ 30 % Conc., T_{5-} Aak extract @ 20 % Conc., T_{6-} Aak extract @ 30 % Conc., T_{7-} Imidacloprid @ 2 % Conc., T_{8-} Imidacloprid @ 3 % Conc., T_{9-} Chemical Check Carbosulphan 25 EC @ 2% Conc. and T_{10-} Untreated Check, were taken. Day to day care was done and after 45 days of sowing, the seedlings were uprooted from each replication for observation at nursery level. The weight of 10 seedlings and root gall index were recorded. After taking the observations, seedlings were dipped in different concentrations of plant extracts and chemicals for 4 hours. Treated seedlings were transplanted in main field each treatment was replicated three times. Yield was recorded at every picking, soil and root population and final root gall index was observed at the time of harvesting of the crop.

Estimation of Soil Population:

Initially 100 cc soil of each sample was processed using Cobb's sieving and decanting technique (Cobb's 1918), followed by Baermann's funnel technique (Cristie and Perry, 1951). After 24 hours, suspension was drawn in a beaker from funnel and kept for some time to allow the nematode to settle down at the bottom. Upper water layer from the beaker was gently removed in order to have a concentrated nematode population. The volume of the suspension was maintained to 100 ml, from this maintained suspension 10 ml nematode suspension was drawn with the help of a pipette and poured over a counting dish. The root-knot nematode larvae were identified and counted under stereoscopic binocular microscope. Dilution count method was used for estimation of number of *Meloidogyne* juveniles.

Identification of Root-knot Nematode:

Root-knot nematode infested roots were washed thoroughly and stained with 0.1 per cent acid fuchsin lacto phenol at 80 ^{o}C for 2-3 minutes (Mc Beth *et al.* 1941). After a gentle wash in tap water, roots were kept in clear lacto phenol for at least 24 hours and then examined under stereoscopic binocular microscope. After staining the females were teased out from the roots and perineal pattern were prepared (Tylor and Netscher, 1974), compared with the 'key' given by Tayler *et al*. (1955) and identified as *M. incognita*.

III. Results

Management of root-knot nematode was tried in tomato where the seedlings after 45 days of sowing were lifted and root-dip treatments were given through botanical extracts and chemical with two concentrations search the best botanical extract and chemical. All the treatments were significantly superior to manage the root-knot disease, reduce final nematode population rests of treatments (14183, 13072 and 13628) in 2014, 2015 and pooled average of both the years and increased tomato yield (237.50, 251.04 and 244.27 q/ha) in 2014, 2015 and pooled average of both the years, as compared to untreated control (145.83 q/ha) in 2014, 2015 and pooled average of both the years which was 62.86, 72.14 and 67.50 per cent higher over control.

Four hours root dip in Neem (*A. indica*) botanical extract solution was better than other botanical extract root-dip to register lowest RKI at harvest (3.20, 3.01 and 3.10) in 2014, 2015 and pooled average of both

the years, final nematode population were recorded (14163, 11852 and 13008) in 2014, 2015 and pooled average of both the years, the fruit yield was maximum (237.50, 250.00 and 243.75 q/ha) in 2014, 2015 and pooled average of both the years.

Imidacloprid chemical was found superior as compared to botanical extracts root-dip to register lowest RKI at harvest (2.32, 2.35 and 2.33) in 2014, 2015 and pooled average of both the years, final nematode population (6813, 7431 and 7122) in 2014, 2015 and pooled average of both years, fruit yield was maximum (285.42, 289.58 and 287.50 q/ha) in 2014, 2015 and pooled average of both the years which was significantly superior as compared to Neem plant extract with 20.17, 15.83 and 17.95 per cent significant superiority.

As regard the concentration levels of botanicals and chemical second concentration level 30 per cent and root dip treatment was statistically superior to first concentration level 20 per cent for the management of root-knot nematode.

Root-dip treatment to be given in 30 per cent concentration which reduced the nematode multiplication, recorded minimum final nematode population (10603, 10327 and 10465) in 2014, 2015 and pooled average of both the years and increase tomato yield (258.33, 268.75 and 263.54 q/ha) in 2014, 2015 and pooled average of both the years which gave 19.22, 15.18 and 17.12 per cent higher yield of tomato over 20 per cent concentration.

Tomato seedlings raised in naturally infested field were lifted after 45 days from of sowing and bare root-dip treatments were given with seedlings were dipped in different concentrations of plant extracts *viz*., Neem (*A. indica*), Jatropha (*Jatropha curcas*) and Aak (*Calotropis gigantea*) of 20 and 30 per cent concentrations and chemical *viz*., Imidacloprid of 2 and 3 per cent concentration for bare root dip treatment exposure time of period was 4 hours treated seedlings were transplanted in main field of each. The treatments were compared with untreated control.

The observations recorded on yield quintals / ha., root gall index (RKI at harvest) and final nematode population in soil + root revealed that statistically there was significant difference between the botanical extracts, chemical Imidacloprid and there concentrations.

IV. Discussion

The superior results were recorded with the Neem (*Azadirachta indica*) plant extract with 30 per cent concentration in all kind of botanicals observations were recorded highest yield of tomato in quintals per hectare lowest root knot index and finally observed the final nematode population which was lowest. This finding agreement with Mohammad, (2000) worked out on symptoms of root gall caused by *Meloidogyne incognita* were significantly reduced by the bare root-dip treatment of tomato (*Lycopersicon esculentum*) seedlings in a neem based commercial product and in an aqueous extract of neem seeds. Khanna, *et al.* (2010) an experiment was conducted under field conditions to assess the efficacy of nursery treatments with carbofuran and root dips in three nematicidal formulations based on plant extracts. *Bacillus subtilis* increased the gerbera growth and quality parameters and decreased the nematode population (Manu and Subramanian, 2016).

Among the chemical Imidacloprid with 3 per cent concentration observations were recorded positively in favors of tomato yield. Yield of tomato was highest and reduced the RKI at harvest and final nematode population was lower as compare to other kind of botanical plant extracts. This research findings agreement with Asawalam and Adesiyan (2001) to compare the nematicidal potential of Cabofuran (Furadan) and *Azadirachta indica* (neem) leaf extract against root-knot nematode (*M. incognita*) on okra. Manage the population of *Helicoverpa armigera* by rhizome hexane extract of *Acorus calamus* (Matharu and Mehta, 2016).

Further, the greater absorption of toxicant by roots and its translocation into the system had also resulted in an adverse effect on the seedlings, when these were given bare root dip treatment for prolonged period i.e., of 4 hours.

Experimental results are in agreement with the Damadzadeh and Hague (1979) who observed better nematode control with root-dip treatments in nematicides, whereas they found that granular application of the tested nematicides did not control the nematodes significantly. Grandison (1983) also tried bare root dip treatments on similar lines and found varying degree of control. Shetty and Reddy (1985) used phenamiphos and aldicarb sulfone and found that the nematicides were also effective at lower period of exposure. Singh *et al.* (1995) suggested the exposure time upto 3 hours for the significant reduction in root-knot nematode population. Sharma and Sharma (1995) found root dip treatment in carbosulfan; phosphamidon and triazophos gave significantly higher yield and reduced galling. These findings are again in confirmation to results of the present investigations. Krishnaprasad and Krishnappa (1981) reported phytotoxic effect of DBCP even at low concentrations in seedling dip treatments, Javed *et al.* (1997) tried seedling dip in methamidophos, monocrotophos, methyl parathion, cypermethrin and fenvelrate for root-knot control on tomatoes and reported phytotoxic effect at 150 ppm except methamidophos. In the present investigation in relation to research findings although phytotoxicity as such was not visible, but root dip treatment for period of exposure 4 hours has resulted in increasing yield parameters and reduced final nematode population.

The results on the management of root-knot nematode by bare root dip treatment have indicated that restricting the development and multiplication of nematodes and increasing the fruit yield of tomato, however, the concentrations of botanicals and Imidacloprid behaved differently. Higher concentration i.e., 30 per cent proved better over 20 per cent and in Imidacloprid 3 per cent proved better over 2 per cent in all respects. Jain and Bhatti (1978) tried 9 different chemicals and found best control of root-knot nematode on tomato by seedling dip treatment over a concentration range of 250 to 1000 ppm, however, 750 and 1000 ppm for 6 hours were observed phytotoxic.

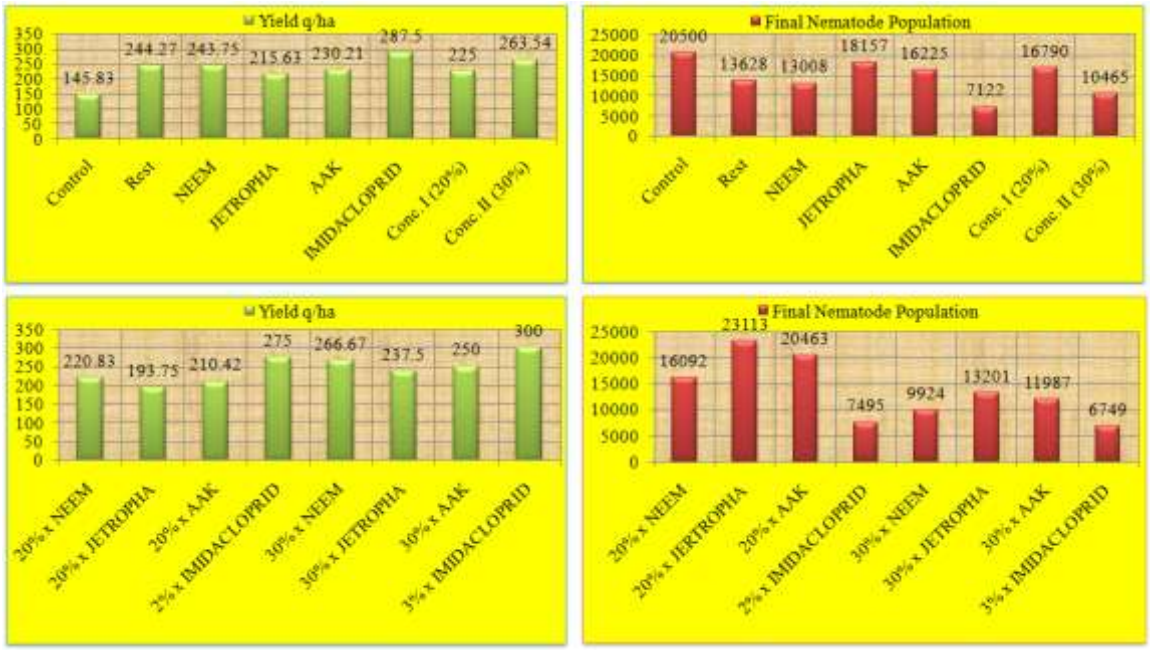
Reddy and Singh (1979) could obtain the lower gall index in 1000 ppm just by 15 and 30 min. seedling dip. Contrarily, Sinha and Roy (1981) successfully employed dimethoate, demeton-methyl, carbofuran and quinalphos by dipping in concentrations upto 2000 ppm even upto 6 hours. In the present studies, bare root dips at 30 per cent concentration for 4 hours have improved nematode control parameters and increase the yield of tomato. It is therefore, suggested that concentrations and botanical extracts and chemical. The research finding agreement with the Iram and Siddiqui (2005) screened out the extract of *Azadirachta indica*, neem seed cake extract and carbofuran, applied singly or in combination through bare root-dip treatment for 60 or 120 minutes, significantly reduced root-knot nematode (*M. incognita*) penetration into the roots of tomato (cv. Pusa Ruby). Sharma *et al.* (2006) conducted an experiment on the management of root-knot nematode, *M. incognita* in chilli through bare root-dip treatment. Wee and Ruelo (1997) worked out varying concentrations of eight pesticides and suggested that if high yield is the target, pericur 625 ppm may be utilized as it also significantly controls the root-knot on tomato. On chillies, Yadav (1988) could obtain increase in yield up to 59.32 per cent by root-dip treatments in various nematicides. Meena *et al*. (2013) examined formulation of four plant leaf extracts namely neem (*Azadirachta indica*), jatropha (*Jatropha curcas*), karanj (*Pongamia pinnata*) and castor (*Ricinus communis*) were used as root-dip treatment at 10 and 20 per cent concentrations were found most effective against root knot nematode management.

Table: Management of root-knot nematode in tomato through bare root dip-treatment.

Treatments	**Yield (q/ha)**			**RKI Final**			**FNP (100 cc Soil + Roots)**		
	2014	**2015**	**Pooled**	**2014**	**2015**	**Pooled**	**2014**	**2015**	**Pooled**
Control v/s Rest									
Chemical Check	325.00	312.50	318.75	1.87	1.97	1.92	4882	4632	4757
Untreated Check	145.83	145.83	145.83	4.23	4.77	4.50	16446	24555	20500
Rest	**237.50**	**251.04**	**244.27**	**3.20**	**3.01**	**3.11**	**14183**	**13072**	**13628**
'F' test	S	S	S	S	S	S	S	S	S
Plant Extracts & Imida									
Azadirachta indica	**237.50**	**250.00**	**243.75**	**3.20**	**3.01**	**3.10**	**14163**	**11852**	**13008**
Jatropha curcas	204.17	227.08	215.63	3.78	3.48	3.63	18155	18159	18157
Calotropis gigantea	222.92	237.50	230.21	3.48	3.22	3.35	17603	14847	16225
Imidacloprid	**285.42**	**289.58**	**287.50**	**2.32**	**2.35**	**2.33**	**6813**	**7431**	**7122**
SEm±	6.78	8.39	5.39	0.08	0.10	0.06	386.04	494.29	313.59
CD at 5 %	20.15	24.91	15.47	0.23	0.29	0.18	1146.99	1468.61	899.42
Extracts concentration									
Concentration-I (20 %)	216.67	233.33	225.00	3.47	3.30	3.38	17764	15817	16790
Concentration-II (30 %)	**258.33**	**268.75**	**263.54**	**2.93**	**2.73**	**2.83**	**10603**	**10327**	**10465**
SEm±	4.80	5.93	3.81	0.06	0.07	0.04	272.97	349.52	221.74
CD at 5 %	14.25	17.62	10.94	0.16	0.21	0.13	811.04	1038.46	635.99
Extracts x Concentrations									
Azadirachta indica x 20 %	212.50	229.17	220.83	3.60	3.28	3.44	17821	14363	16092
Jatropha curcas x 20 %	183.33	204.17	193.75	4.03	3.93	3.98	23217	23010	23113
Calotropis gigantea x 20 %	200.00	220.83	210.42	3.80	3.53	3.67	22742	18184	20463
Imidacloprid x 2 %	270.83	279.17	275.00	2.43	2.43	2.43	7278	7712	7495
***Azadirachta indica* x 30 %**	**262.50**	**270.83**	**266.67**	**2.80**	**2.73**	**2.77**	**10506**	**9342**	**9924**
Jatropha curcas x 30 %	225.00	250.00	237.50	3.53	3.03	3.28	13094	13308	13201
Calotropis gigantea x 30 %	245.83	254.17	250.00	3.17	2.90	3.03	12464	11510	11987
Imidacloprid x 3 %	**300.00**	**300.00**	**300.00**	**2.20**	**2.27**	**2.23**	**6349**	**7150**	**6749**
SEm±	6.78	8.39	7.63	0.08	0.10	0.09	386.04	494.29	443.48
CD at 5 %	NS	NS	NS	NS	NS	0.26	1146.99	1468.61	1271.97

INP = Initial Nematode Population /100 cc soil	2014	2015	Pooled	Time: For root dip: 4 hours
Nursery	451	461	456	
Field	460	470	465	

Fig.: Effect of different treatments of seedling root-dip on tomato yield and root-knot nematode population individual and interaction.



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