Management ofRootKnotnematode*Meloidogyne incognita* on carrot

ABSTRACT

Experiments were conducted to find out the efficacy of certain botanicals like *Azadirachta indica, Azeratumconizoides, Tageteserecta, Ricinus Communis, Lantana camara* and*Parthenium hysterophorus* and different biocontrol agents like *Glomusfasciculatum*, consortia (*T. harzianum, T. viride* and *Pseudomonas fluorescenes*) and vermicompost for the management of *M. incognita* on carrot. The treatment with *A. indica* @ 1.5% (w/w)among the botanicals and the treatment with *G. fasciculatum* @ 300 spores/m^2 + consortia @ 5ml/lt + vermicompost @ 1.25t/ha was found most effective in increasing plant growth parameters and in decreasing the *M. incognita* infection on carrot.

Key words: Botanicals,*Azadirachta indica, Azeratumconizoides, Tageteserecta, Ricinus Communis, Lantana camara, Parthenium hysterophorus*, biocontrol agents ,*Glomusfasciculatum*,*T. harzianum, T. viride*, *Pseudomonas fluorescenes*, vermicompost ,*M. incognita*, carrot.

INTRODUCTION

Carrot (*Daucus carota*) is an important and common vegetable crop grown throughout the world .Out of different plant parasitic nematodes, root knot nematodes (*Meloidogyne* spp) causes considerable damage to the cropwith an yield loss of 59.3percent (Sreenivasan, 2017) due to attack of *M.* spp.Disease management through eco-friendly biological approaches is becoming inevitable which is safe for both user and treated crop, compared to synthetic chemicals.

MATERIALS AND METHODS

Apot experiment was conducted in the net house of Department of Nematology, AAU, Jorhat to know the efficacy of certain botanicals against *M. incognita* on carrot. Earthen pots of 1kg capacity were filled up with sterilized soil and inoculated with J_2 of *M. incognita* @ 1000 J_2 per pot. The soil was incorporated with chopped leaves of *Azadirachta indica, Azeratumconizoides, Tageteserecta, Ricinus Communis, Lantana camara, Parthenium hysterophorus*each @ 1.0 and 1.5% (w/w). One treatment was kept as control without application of botanicals. After ten days, three seeds of carrot variety, 'Early nantes' was sown in each pot. Each treatments was replicated five times and arranged in a completely randomized design. The pots were watered regularly for proper decomposition. The treatments taken in the investigations were: T_1:*A. indica* @1.0% (w/w), T_2: *A. indica*@1.5% (w/w),T_3: *A.conizoides* @1.0% (w/w), T_4: *A.conizoides* @1.5% (w/w), T_5: *T. erecta* @1.0% (w/w), T_6: *T.erecta* @1.5% (w/w), T_7:*R. communis* @1.0% (w/w), T_8: *R. communis* @1.5% (w/w),T_9: *L.camara*@1.0% (w/w), T_{10}: *L.camara*@1.5% (w/w), T_{11}: *P.hysterophorus*@1.0% (w/w), T_{12}: *P.hysterophorus* @1.5% (w/w), T_{13}: Control.After ninety days of sowing, plants were uprooted carefully and roots were washed free of soil. Observations on different plant growth parameters *viz.*,length of shoot and tap root, fresh and dry shoot and tap root weight,number of galls and eggmasses and final nematode population in soil were recorded.

The microplot experiment was conducted during the *rabi* season of 2015-16 to study the efficacy of *Glomusfasciculatum,* consortia (*T. harzianum, T. viride* and *Pseudomonasfluorescenes*) and vermicompost for the management of *M. incognita* on carrot. For this microplots infested with *M. incognita* (1-2 J_2 per gram soil) of

1x1 m^2 size were used and recommended dose of manure and fertilizers were applied. Initial population of *M. incognita* in different microplots of size 1x1 m^2 size were recorded. Vermicompost was applied 10 days before sowing. Carrot seeds were sown in rows at the spacing of 30 cm between rows and 10 cm from plant to plant. Consortia and *G. fasciculatum* were applied at the time of sowing. The experiment was laid out in a Randomized block design with following treatments and each treatment was replicated three times. The different treatments were: T_1: Soil application of consortia @ 5ml/ltr/m^2 ,T_2: Vermicompost @ 2.5t/ha, T_3: *G.fasiculatum*@ 600 spores/m^2, T_4: Soil application of consortia @ 5ml/ltr+ vermicompost @ 1.25t/ha, T_5: Soil application of consortia @ 5ml/ltr + *G.fasiculatum*@ 300 spores/m^2, T_6:Vermicompost @ 1.25t/ha +*G. fasiculatum*@ 300 spores/m^2, T_7 : Soil application of consortia @ 5ml/ltr+ vermicompost @ 1.25t/ha +*G. fasiculatum*@300spores/m^2, T_8 : Control.Observations were taken at full maturity. For this 10 plants from each plot were uprooted randomly and roots were washed carefully in tap water to remove adhering soil particles. Records on length of shoot and tap root, fresh and dry weight of shoot and tap root, number of galls per root system, number of healthy and forked tap root per plot, yield per plot (q/ha) and final nematode population in soil were recorded.

RESULT AND DISCUSSION

The results of the pot experiment exhibited maximum increase in plant growth in the treatment with *A. indica* @ 1.5% (w/w) (Table 1) . All the treatments were found to be effective in increasing growth parameters of carrot over control.These results are in agreement with John and Hebsy (2000) who reported that bare root dip of brinjal seedlings in neem leaf extract significantly increased the plant growth parameters. This may be due to the presence of azadirachtin, a major nematotoxic compound in neem which is released through volatilization, exudation, leaching and de-composing of the plant parts that suppress the population of plant parasitic nematode and helps in growth of plant (Akhtar, 2000).

Maximum reduction in number of galls,eggmasses and final nematode population in soil were also recorded in the treatment with *A. indica* @ 1.5% (w/w) (Table 2). This may be due to the presence of terthienyl and bithienyl compounds, the toxic principle of marigold, (Uhlenbroek and Bijloo, 1958). Similar findings were also observed by Nelaballe and Mukkara (2013) who reported that leaf extracts of *Datura stramonium*, *Azadiracta indica*, *Calotropis procera* and *Crotalaria juncea* reduced the infestation of *M. incognita* in mulberry plant among which the highest juvenile mortality (82.8%) was recorded with neem extract. This may be due to the presence of active toxic principles like azadirachtin and nimbin in *A. indica* and thiophene and alpha-terthienyl in *T. erecta*, suppress the nematode population as well as improved plant growth. (Rao and Parmer, 1984).

The result of the microplotexperiment revealed that maximum increase in plant growth parameters were recorded in the treatment with *G. fasciculatum* @ 300spores/m^2 + consortia @ 5ml/lt + vermicompost @ 1.25t/ha (Table 3).Nama *et al.* (2015) also reported that talc based formulation of *T.viride, T. harzianum, P. flourescenes* against *M. incognita,* significantly increased the plant growth characters and reduced nematode reproduction as compared to untreated checks on

cowpea. *Trichoderma* sp is highly rhizosphere competent i.e., able to colonize on roots as it develops, thus promote plant growth. It may also exert several mechanisms such as tolerance to stress through enhanced root and plant development, induced resistance, inactivation of pathogen's enzymes in improving plant growth and suppressing plant pathogens(Weeder*et al.;* 2008).

Maximum decrease in number of galls and final nematode population werealso recorded in the treatment with *G. fasciculatum* @ 300 spores/m^2 + consortia @ 5ml/l + vermicompost @ 1.25t/ha. All the treatments were found to be effective in reducing the number of galls, eggmasses and final nematode population over control (Table 4). Similar findings were also recorded by Masadeh*et al.* (2004) who reported that combination of the arbuscular mycorrhizal fungus *G. intraradices* and the fungus *T. viride*retarded the development of the giant cell system, growth of the nematode, consequently reduced production of egg-masses and nematode population. The reduction in number of galls, eggmasses and also the nematode population in soil in mycorrhizal treatments may be due to increased resistance by mycorrhizal plants to nematodes or due to colonization of the roots by *G. fasciculatum*which mechanically prevents the entry of *M. incognita* into the roots of tomato (Mittal *et al.*, 1991). Reduction of nematode due to *T. harzianum* may be attributed to the direct parasitism of eggs and larvae through the increase in chitinase and protease activity, which could be indicator of eggs and infection capabilities. Sharon *et al.* (2001) reported two mechanisms involved in *Trichoderma* antagonism against root-knot nematode (i) *Trichoderma* produced metabolites with antinematode activity that immobilized J_2 thus reduced root penetration and (ii) direct parasitism by *Trichoderma.*

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Table 1. Effectof botanicals on the plant growth of carrot. (Mean of 5 replications)

Treatments	Shoot length (cm)	Tap root length (cm)	Fresh weight of shoot (g)	Dry weight of shoot (g)	Fresh weight of tap root (g)	Dry weight of tap root (g)
T_1 :*Azadirachta indica* @ 1.0% (w/w)	38.76 ^{c}	18.72 ^{c}	9.12 ^{a}	5.54 ^{c}	28.08 ^{b}	17.76 ^{c}
T_2 :*A. indica* @ 1.5% (w/w)	43.10 ^{a}	19.48 ^{a}	9.22 ^{a}	6.84 ^{a}	29.70 ^{a}	18.94 ^{a}
T_3 :*Azeratumconizoides*@ 1.0% (w/w)	27.00 ^{i}	14.08 ^{h}	7.16 ^{f}	3.58 ^{g}	22.72 ^{fg}	12.90 ^{i}
T_4 :*A. conizoides*@ 1.5% (w/w)	28.24 ^{h}	15.00 ^{g}	7.48 ^{e}	4.14 ^{f}	23.12 ^{ef}	13.00 ^{i}
T_5 :*Tagetes erecta* @ 1.0% (w/w)	36.16 ^{d}	17.58 ^{d}	8.94 ^{a}	5.04 ^{d}	26.12 ^{c}	17.20 ^{d}
T_6 :*T. erecta* @ 1.5% (w/w)	40.26 ^{b}	18.00 ^{b}	9.14 ^{a}	6.14 ^{b}	28.08 ^{b}	18.20 ^{b}
T_7 :*Ricinus communis* @ 1.0% (w/w)	33.70 ^{e}	16.26 ^{f}	8.36 ^{bc}	4.04 ^{f}	24.12 ^{d}	15.82 ^{f}
T_8 :*R. communis* @1.5% (w/w)	34.08 ^{e}	17.00 ^{e}	8.50 ^{b}	4.46 ^{e}	26.08 ^{c}	16.76 ^{e}
T_9 :*Lantana camara*@1.0% (w/w)	29.32 ^{g}	15.04 ^{g}	8.00 ^{d}	4.00 ^{f}	23.20 ^{e}	13.92 ^{h}
T_{10}: *L. camara*@ 1.5% (w/w)	31.62 ^{f}	16.02 ^{f}	8.12 ^{cd}	4.06 ^{f}	24.00 ^{d}	14.94 ^{g}
T_{11} :*Parthenium hysterophorus*@1.0% (w/w)	25.00 ^{k}	13.26 ^{i}	7.00 ^{f}	3.14 ^{h}	22.58 ^{g}	11.98 ^{j}
T_{12} : *P. hysterophorus* @1.5% (w/w)	26.06 ^{j}	13.96 ^{h}	7.10 ^{f}	3.24 ^{h}	22.92 ^{efg}	12.08 ^{j}
T_{13} : control	20.84 ^{l}	10.04 ^{j}	4.98 ^{g}	3.12 ^{h}	18.16 ^{h}	9.26 ^{k}
S.Ed (±)	0.29	0.17	0.15	0.11	0.20	0.20
$CD_{0.05}$	0.58	0.34	0.30	0.23	0.40	0.42

Table2 . Effectof botanicals on *Meloidogyne incognita* on carrot(Mean of 5 replications)

Treatments	No. of galls	No. of egg mass	Final nematode population	% decrease over control
T_1 :*Azadirachta indica* @ 1.0% (w/w)	14.80 $(3.84)^{k}$	11.00 $(3.08)^{ij}$	121.60 $(11.02)^{i}$	61.34
T_2 :*A. indica* @ 1.5% (w/w)	14.20 $(3.76)^{k}$	8.60 $(3.01)^{j}$	99.00 $(9.94)^{l}$	68.53
T_3 :*Azeratumconizoides* @ 1.0% (w/w)	33.80 $(5.81)^{d}$	25.80 $(5.07)^{d}$	151.60 $(12.31)^{d}$	51.81
T_4 :*A. conizoides* @ 1.5% (w/w)	31.80 $(5.63)^{e}$	23.60 $(4.85)^{e}$	144.40 $(12.01)^{e}$	54.10
T_5 :*Tagetes erecta* @ 1.0% (w/w)	21.60 $(4.64)^{j}$	9.60 $(3.17)^{i}$	101.00 $(10.04)^{k}$	59.94
T_6 : *T. erecta* @ 1.5% (w/w)	14.40 $(3.79)^{k}$	9.00 $(3.08)^{ij}$	100.80 $(10.03)^{k}$	66.87
T_7 :*Ricinus communis* @ 1.0% (w/w)	27.80 $(5.27)^{h}$	17.40 $(4.17)^{g}$	131.20 $(11.45)^{h}$	58.29
T_8 : *R. communis* @1.5% (w/w)	23.80 $(4.87)^{i}$	14.20 $(3.76)^{h}$	110.80 $(10.52)^{j}$	64.78
T_9 :*Lantana camara* @1.0% (w/w)	30.40 $(5.51)^{f}$	22.80 $(4.77)^{e}$	138.40 $(11.76)^{f}$	56.00
T_{10} :*L. camara* @ 1.5% (w/w)	29.20 $(5.40)^{g}$	19.40 $(4.40)^{f}$	134.20 $(11.58)^{g}$	57.34
T_{11} :*Parthenium hysterophorus* @1.0% (w/w)	38.20 $(6.18)^{b}$	30.80 $(5.54)^{b}$	159.00 $(12.60)^{b}$	49.45
T_{12} : P. hysterophorus @1.5% (w/w)	35.00 $(5.91)^{c}$	27.80 $(5.27)^{c}$	154.20 $(12.41)^{c}$	50.98
T_{13} : control	47.40 $(6.88)^{a}$	37.20 $(6.09)^{a}$	314.60 $(17.73)^{a}$	
S.Ed (±)	0.05	0.05	0.03	
CD0.05	0.10	0.11	0.06	

Table3. Effectof *Glomus fasciculatum*,consortia and vermicompost on plant growth and yield of carrot(Mean of 3 replications)

Treatments	Shoot length (cm)	Tap root length (cm)	Number of healthy tap root per plot	Forked tap root per plot (%)	Yield (q/ha)	% increased over control
T_1 = Soil application of consortia @ 5ml/ltr	41.03 ^{e}	13.03 ^{f}	19.00 ^{e}	32.20 ^{b}	120.00 ^{e}	24.16
T_2 = Vermicompost @ 2.5 ton/ha	41.23 ^{e}	14.03 ^{e}	19.66 ^{de}	28.86 ^{bc}	123.33 ^{e}	27.59
T_3 = *G. fasciculatum*@ 300 spores/m^2	39.83 ^{f}	12.00 ^{g}	18.00 ^{e}	31.20 ^{b}	106.66 ^{f}	10.34
T_4 = Soil application of consortia @ 5ml/ltr + vermicompost @ 1.25 t/ha	45.13 ^{c}	16.23 ^{c}	22.00 ^{c}	21.06 ^{d}	150.00 ^{c}	55.24
T_5 = Soil application of consortia @ 5ml/ltr + *G. fasciculatum* @ 300 spores/m^2	43.03 ^{d}	15.00 ^{d}	21.00 ^{cd}	24.40 ^{cd}	136.66 ^{d}	41.44
T_6 =*G. fasciculatum* @ 300 spores/m^2 + vermicompost @ 1.25 t/ha	47.93 ^{b}	18.86 ^{b}	24.00 ^{b}	14.40 ^{e}	166.66 ^{b}	72.41
T_7 = Soil application of consortia @ 5ml/ltr + *G. fasciculatum* @ 300 spores/m^2 + vermicompost @ 1.25 t/ha	49.63 ^{a}	20.56 ^{a}	26.00 ^{a}	8.86 ^{e}	176.66 ^{a}	82.82
T_8 = control.	37.83 ^{g}	10.96 ^{h}	14.00 ^{f}	44.43 ^{a}	96.66 ^{g}	
S.Ed(±)	0.14	0.21	0.80	2.74	3.72	
$CD_{0.05}$	0.31	0.47	1.72	5.89	7.99	

Table 4. Effectof *Glomus fasciculatum,* consortiaand vermicompost on *Meloidogyne incognita* on carrot(Mean of 3 replications)

Treatments	No. of galls	Final nematode population in soil	% decrease over control	% increase/ decreased over INP
T_1 = Soil application of consortia @ 5ml/ltr	20.83 (4.56)c	183.33 (13.53)c	48.01	-29.91
T_2 = Vermicompost @ 2.5 t/ha	21.04 (4.58)c	181.00 (13.45)c	48.67	-27.90
T_3 = *G. fasciculatum*@ 300 spores/m^2	23.16 (4.81)b	186.66 (13.66)b	47.07	-15.99
T_4 = Soil application of consortia @ 5ml/ltr + Vermicompost @ 1.25 t/ha	17.43 (4.17)d	171.66 (13.10)e	51.32	-32.26
T_5 = Soil application of consortia @ 5ml/ltr + *G. fasciculatum*@ 300 spores/m^2	18.16 (4.26)d	176.66 (13.29)d	49.90	-40.74
T_6 =*G. fasciculatum*@ 300 spores/m^2 + vermicompost @ 1.25 t/ha	16.90 (4.11)d	169.00 (12.99)f	52.07	-45.67
T_7 = Soil application of consortia @ 5ml/ltr + *G. fasciculatum*@ 300 spores/m^2 + vermicompost @ 1.25 t/ha	13.38 (3.65)e	163.66 (12.79)g	53.59	-43.21
T_8 = control.	32.38 (5.69)a	352.66 (18.77)a		+23.45
S.Ed±	0.08	0.04		
$CD_{0.05}$	0.19	0.09		