Management ofRootKnotnematode*Meloidogyne incognita* on carrot

ABSTRACT

A pot experiment was conducted in the net house, Department of Nematology, during the rabi season to know the efficacy of certain botanicals, *Azadiracta indica, Azeratum conizoides, Tageteserecta, Ricinus Communis, Lantana camara* and*Parthenium hysterophorus* each @ 1.0 and 1.5%(w/w) against *Meloidogyne incognita* on carrot.The result revealed that all the treatments were effective in increasing plant growth parameters with corresponding decreased in number of galls, eggmasses per root system and final nematode population in soil over control. The treatment with *Azadiracta indica* @1.5%(w/w) was most effective in increasing plant growth characters, reducing number of galls, eggmasses per root system and final nematode population in soil.

A microplot experiment was conducted during rabi season to study the efficacy of*Glomusfasciculatum*, consortia (*T. harzianum, T. viride* and *Pseudomonas fluorescenes*) and vermicompost for the management of *M.incognita* on carrot. All the treatments were effective in increasing plant growth parameters and yield with corresponding decreased in number of galls, eggmasses per root system and final nematode population in soil over control.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,yield of carrot and reducing number of galls and eggmasses and final nematode population in soil.

Key words: Botanicals,*Azadirachta indica*, *Azeratum conizoides, 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.Nematode infestation in carrot can cause significant damage to crops, leading to decreased yield and quality.Out of different plant parasitic nematodes, root knot nematode (*Meloidogyne* spp) cause considerable damage to carrot with an yield loss of 59.3 percent"(Sreenivasan, 2017)."The root knot nematode cause symptoms including galling, forking, stubbing and fasciculation of the roots, which can impair the commercial value of carrots for fresh vegetable markets"(Bridge and Starr,2007). Disease management through eco-friendly biological approaches is becoming inevitable which is safe for both user and treated crop, compared to synthetic chemicals. The main carrot growing states in India are Haryana, Punjab, Karnataka and Andhra Pradesh.In India carrot is cultivated with an area of 62,410 ha and production of 1073710 MT (Anon., 2014).In Assam, carrot is cultivated as rabi vegetables during the month of October to December. Carrot has a total production of 77.53 ton in Assam (Anon., 2022).

MATERIALS AND METHODS

Pot Experiment

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*, *Azeratum conizoides, 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.

Microplot Experiment

The microplot experiment was conducted during the *rabi* season to study the efficacy of *Glomusfasciculatum*, consortia (*T. harzianum, T. viride* and *Pseudomonas fluorescenes*) 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/m^2+ 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

Pot experiment

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).

Khan et.al (2019) observed that "maximum mortality of *M. incognita* (91%) in 5000 ppm extract of *Phyllanthus amarus* after 72 hours of exposure with LC_{50} value 2084.49 ppm while minimum mortality (6.2%) was found in 1000 ppm extract of *Trianthema portulacastrum* after 24 hours with LC_{50} value of 9484.18 ppm".

Khan et.al (2021) evaluated "the nematicidal potential of chitosan in combination with chopped leaves *Argemone mexicana* L., *Achyranthes aspera* L., and *Ricinus communis* L. against infestation caused by *M.incognita* on carrot under both *in vitro* and *in vivo*. Maximum mortality of J_2 and the highest inhibition in egg hatching was observed at 2500 ppm of chitosan and after 36 hours of incubation period, respectively . Furthermore, pots treated with 1g chitosan and 30g of freshly

chopped leaves of all three tested botanicals significantly reduced pathological parameters and improved growth and photosynthetic attributes of carrot".

Mohammed Ikram et. al.(2023) studied "the efficacy of botanicals viz.*Commelina benghalensis, Evolvulus nummularius, Gomphrena celosioides, Lindenbergia indica, Scoparia dulsis and Vernonia cinerea*under the pot condition. They found that the pot treated with the amendment of fresh leaves(60g) of selected botanicals with dried powder 10g of *L.indica* efficiently reduced the infestation caused by *M.incognita* on carrot along with significantly increased growth and biochemical attributes. They observed that various volatile compounds in leaf extracts of *L.indica* and *S.dulcis* leaves, out of which phytol was a major compound which suppress the infestation of *M.incognita* and increase the yield of carrot".

Microplot experiment

The result of the microplot experiment 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 were also 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".*

Pedroche et.al (2009) observed that root knot nematode population can be suppressed by addition of organic amendment and improve the growth and yield of more susceptible and less susceptible carrot cultivar in comparison with farmer's practice in microplot condition.

Nagachandrabose et.al (2018) observed "the field efficacy of *Pseudomonas fluorescence*, *Purpureocillium lilacinum* and *T. viride* liquid formulations against natural populations of root knot nematode *M. hapla.* Two field experiments were conducted to test the effect of these biocontrol agents by seed treatments at 100ml/kg of seeds and by soil drenching at 5L/ha, their effect was compared with that of Carbofuran 3G at 1kg a.i per ha. Results showed that all the tested

biocontrol agents were capable of reducing *M.hapla* juvenile(J_2) populations in soil, infection of female population in roots and egg numbers per gram of root at various levels.The *P.flourescence*(Seed Treatment) caused greatest reduction of J_2 populations(67-69%) in soil, female infection(67-69%) in roots and egg numbers per gram of root (68-69%). It is concluded that *P.flourescence*-Seed Treatment at 100ml/kg of seeds and *P.lilacinum*-Soil drenching at 5L/ha are highly effective for the management of *M.hapla*,which infects carrot under field condition".

CONCLUSION

Studies on the use of chopped leaves for the management of *M. incognita* on carrot showed that the treatment with *A. indica* @1.5%(w/w) was found to be most effective in increasing plant growth characters, reducing number of galls, eggmasses per root system and final nematode population in soil.

In the microplot experiment all the treatment with *G.fasciculatum*, consortia (*T. harzianum, T. viride* and *P. fluorescenes*) and vermicompost alone or in combination significantly increased plant growth parameters , yield of carrot and decreased in number of galls, eggmasses per root system and final nematode population in soil . 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, yield of carrot and reducing number of galls and eggmasses and final nematode population in soil.

REFERENCES

Anon., (2022) National Horticultural Board. (NHB) pp: 1.

Akhtar, M. (2000) Nematicidal potential of the neem tree *Azadirachta indica* (A. Juss*). Integrated Pest Mangement Reviews*. **5**: 57-66.

Bridge, John and Starr, James(2007) DOI-https://doi.org/10.1201/b15142 PP - 152.

John, A. and Hebsy, B. (2000). Bare-root dip treatment of brinjal seedlings in phytochemicals for the management of root-knot nematodes (*Meloidogyne incognita*). *J. Trop. Agric*. **38**: 69-72.

Khan, Faryad, Asif Mohd, Khan Amir, Tariq Mohd, Ansari Taruba, Shariq Mohd, Siddiqui Mansoor Ahmad(2019) Evaluation of the nematicidal potential of some botanicals against root knot nematode, Meloidogyne incognita infected carrot: *in-vitro* and greenhouse study. *Current Plant Biology*, Volume 20,100115

Masadeh, B.; Von Alten, H.; Stoecker, G. G. and Sikora, R. A. (2004). Biocontrol of root-knot nematodes using the Arbuscular mycorrhizal fungus *Glomus intraradices* and the antagonist *Trichoderma viride* in two tomato cultivars differing in their suitability as host for the nematodes. *J. PlantDis. Protec*. **111**(4): 322-333.

Mittal, N; Sharma, M.; Saxena, G and Mukherjee, K.G. (1991). Effect of VA mycorrhiza on gall formation in tomato roots. *Pl. Celllncompati Newsl*.**23**:39-43

Nama, C.P.; Sharma, H. K. and Siddiqui, A. U. (2015). Efficacy of bio-agents against root-knot nematode, *Meloidogyne incognita* infecting cowpea (*Vigna unguiculata* L.) *Journal ofbiopesticides*,**8**(1): 19-22 .

Nelaballe, V.K and Mukkara, L.D (2013). Study on the nematicidal Effect Of some local flora on *Meloidogyne Incognita* Chit wood Infesting mulberry. *Intn. J . Chemical, Envt. and Biol. Sci.* **1**: 2320-4087.

Pedroche, Nordalyn B; Villanueva, Luciana M. and Waele, Dirk De (2009) Management of Root Knot Nematode, *Meloidogyne incognita* in carrot. *Commun Agric Appl Biol Sci*.; **74**(2):605-15.

Rao, K. N. and Parmer, B. S. (1984). A compendium of chemical constituents of neem, neem. *news lett*, **1**: 39-46

Sharon, E.; Bar-Eyal, M.; Chet, I.; Herrara-Estrella, A.; Kleifeld, D. and Spiegle, Y. (2001). Biological control of the root-knot nematode Meloidogyne javanica by *Trichoderma harzianum*. *Phytopathol*. **91**(7): 687-693.

Sreenivasan, N. (2017). Status of root knot nematode, *Meloidogyne hapla* infection of carrot at Kodaikanal hills of Tamil Nadu, India and its yield loss estimation. *Int. J. Curr. Microbiol. App. Sci*. (2017) **6**(9): 3629-3635.

Uhlenbroek, J.H. and Bijloo, J.D. (1958) Investigation on nematicides. Isolation and structure of a nematicidal principle occurring in Tagetes roots. Recueil des Travaux Chimiques des Pays-Ba. 77, 1004-1008

Weeder, C. R.; Shelton, A. M. and Hoffman, M.P. (2008). Biological control. In : *A guide to Natural Enemies in North America*, pp. 1-14.

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

Treatments	Shoot length (cm)	Tap root length	Fresh weight of shoot (g)	Dry weight of shoot (g)	Fresh weight of tap	Dry weight of tap root

		(cm)			root (g)	(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 : *Azeratum conizoides* @ 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 : *Azeratum conizoides* @ 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		