*Available online at* www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.2447

**ISSN: 2320 – 7051**

*Int. J. Pure App. Biosci.* **5 (1):** 268-276 (2017)

*Research Article*

International Journal of Pure & Applied Bioscience

OPEN ACCESS

# Management of Rice Root-Knot Nematode, *Meloidogyne graminicola*

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Received: 12.01.2017 | Revised: 20.01.2017 | Accepted: 23.01.2017

**ABSTRACT**

*Field experiments were conducted during Kharif 2013-14 to know the efficacy of bio agents viz., Pseudomonas fluorescens, Trichoderma viride, Paecilomyces lilacinus and Pochonia chlamydosporia and organic amendments viz., poultry manure and neem cake and combination of P. fluorescens with carbofuran 3G @ 0.3 ai. and T. viride with carbofuran 3G @ 0.3 ai. and carbofuran 3G alone for management of rice root-knot nematode Meloidogyne graminicola. The results revealed that all the treatments were significantly superior over check with respect to growth parameters and nematode population. However, the treatment combination of Pseudomonas fluorescens @20g/m² + Carbofuran 3G recorded highest plant height (83.26 cm), root length (20.60 cm), maximum grain yield (44.1 q/ha) and least nematode population (132.67/200g soil) with reduction of 79.34% nematode population followed by T. viride @20g/m² + carbofuran with plant height (81.67cm), root length (18.50 cm), grain yield (43.6 q/ha) with least nematode population (198.00/200g soil) with reduction of 69.17% nematode population.*

***Key words:*** *Meloidogyne graminicola, Management, Rice, Root-knot nematode*

## INTRODUCTION

Rice (*Oryza sativa*) is an important staple food crop for majority of human population in the world in general and in Asia in particular. However, among various pests and diseases which constitute important constraints in the successful crop production, plant parasitic nematodes play an important role and account for yield losses to the extent of 90%. The major nematode pests associated with rice are *Ditylenchus angustus, Aphelenchoides besseyi, Hirschmanniella spp., Heterodera oryzicola* and *Meloidogyne graminicola*. However, rice root-knot nematode (*M. graminicola*) happens to be the most important pest and is prevalent in major rice producing countries of the world[1]. Rice is quite susceptible to root-knot nematode and is attacked by *Meloidogyne incognita, Meloidogyne graminicola, Meloidogyne triticoryzae, Meloidogyne javanica, Meloidogyne oryzae* and *Meloidogyne arenaria*[2]. Amongst these species, *M. graminicola* is a primary pest of rice and poses a substantial threat to rice cultivation in particular Southeast Asia where around 90% of the world rice is grown and consumed[3].

**Cite this article:** Narasimhamurthy H.B., Ravindra, H. and Sehgal M., Management of Rice Root-Knot Nematode, *Meloidogyne graminicola*, *Int. J. Pure App. Biosci.* **5(1):** 268-276 (2017). doi: http://dx.doi.org/10.18782/2320-7051.2447

In India, rice is grown in all five major ecosystems[4]. Rice is grown in Karnataka in different Agroclimatic zones with a rainfall pattern varying from 600 to 3000 mm only around 44 per cent of the total acreage is under irrigation while the rest is under the regime of monsoon. In some areas, only one crop is grown and in certain other areas three crops are raised. The unique feature of rice culture in the state is that either sowing or transplanting is seen in all seasons of the year. The duration of the rice varieties cultivated in the state varies from 100 to 180 days depending on season and agro-climatic locations[5]. *M. graminicola* is highly damaging to upland, rain-fed lowland[6] and irrigated rice cultivation[7]. In India, this nematode has been found to cause yield losses of 16 to 32% in rainfed and upland rice[8]. There are various methods of nematode management that may prove effective against rice root-knot nematodes[9]. Despite the known deleterious effects of chemicals, pesticides are still the most effective means of nematode management in rice ecosystems[10]. Several efforts for managing root knot nematode using chemicals are not satisfactory to control; cost of chemicals and residue problems has made the nematode management strategy unattractive for the growers and extension specialists. Chemicalisation of agroecosystem depleted soil biota and withdrawal soil antagonists and beneficial organisms in soil environment promoted harmful plant pathogens including phytoparasitic nematodes. Of late, rice root-knot nematode *Meloidogyne graminicola* has become a serious menace in all type of rice growing situations in Karnataka. As a part of M.Sc Thesis the present investigation was designed to evaluate different bioagents and organic amandements and combination of bioagent with carbofuran for management of rice root knot nematode.

## MATERIALS AND METHODS

### Experimental site

Experiments were carried out in 2013 in a field naturally infested with rice root-knot nematode, *M. graminicola* at College of Agriculture, Zonal Agricultural and Horticultural Research Station, Shivamogga (13° 27'- 14° 39' North latitude and 74° 37'- 75° 52' East Longitude with an altitude of 650 meters above the mean sea level. Karnataka, India). The susceptible variety Jyothi was used for the studies. The experiment was laid out in a randomized complete block design (RCBD) with ten treatments replicated twice. (Figure.1) Twenty four day old seedlings were transplanted in the plots using two seedlings/ hill with a spacing of 20 x20 cm. The crop was transplanted during 4th week of June and 1st week of July.

### Treatment details:

T1= *Paecilomyces lilacinus* @20g/m²
T2= *Pseudomonas fluorescens* @20g/m²
T3= *Pochonia chlamydosporia* @20g/m²
T4=*Trichoderma viride*@20g/m²
T5= Carbofuran 3G @16.6g/m2
T6= Neem cake @100 g/m2
T7=*Trichoderma viride*@20g/m² + carbofuran 3G @16.6g/m2
T8 = *Pseudomonas fluorescens* @20g/m² + carbofuran 3G @16.6g /m2
T9= Poultry manure @ 100g/m2
T10= Untreated control.

The observation on growth parameters such as plant height (cm), root length (cm), root volume (ml), root weight (g) and grain yield per plot, nematode populations in 200cc soil, nematode populations in 5g roots, number of galls/root system were recorded. The soil population of juveniles of *M. graminicola* was determined using Cobb's decanting and sieving method (modified), followed by Baermann's funnel technique[11]. and root knot index was recorded based on 0-5 rating scale according to the number of galls per root system in which 0=No galls(Immune), 1=1-2 galls/root system(Resistant), 2=3-10 galls/root system(Moderately resistant) 3=11-30 galls/root system(Moderately susceptible) 4=31-100 galls/root system (Susceptible) and 5=>100 galls/root system(Highly susceptible)[12].

**Statistical analysis**

The data obtained in the present investigation regarding parameters such as plant height (cm), root length (cm), root volume (ml), root weight (g) and grain yield per plot, nematode populations in 200cc soil, nematode populations in 5g roots, number of galls/root system and number of egg masses/ root system were subjected to statistical analyses for *in-vivo* studies.

## RESULTS AND DISCUSSION

The experiment was carried out with ten treatments during 2013-14. to know the efficacy of bio agents viz., *Pseudomonas fluorescens*, *Trichoderma viride*, *Paecilomyces lilacinus* and *Pochonia chlamydosporia* and organic amendments viz., poultry manure and neem cake and combination of *P. fluorescens* with carbofuran 3G @ 0.3 ai. and *T. viride* with carbofuran 3G @ 0.3 ai. and carbofuran 3G alone for management of rice root-knot nematode *Meloidogyne graminicola.* The results revealed that all the treatments were significantly superior over untreated control with respect to growth parameters and nematode population.

**Effect on Growth parameters:**

**Effect on Plant height**

All the treatments were significantly superior over untreated check (15.93 cm). The plant height of rice in various treatments differed significantly. The plots treated with *P. fluorescens* + carbofuran (25.91cm) was recorded significantly higher plant height which was on par with *T. viride* + carbofuran and Carbofuran (24.66), *P. fluorescens* (24.33 cm), *T. viride* (23.90), *P. chlamydosporia* (23.60 cm) and *Paceillomyces lilacinus* (23.00 cm) respectively at 30 days after transplanting. The similar trends were observed at 60, 90 and at the time harvest (Table.1 and figure.1) In general, *P. fluorescens* + carbofuran, *T. viride* + carbofuran, carbofuran, *P. fluorescens*, and *T. viride* were significantly superior recorded better plant height compared to other treatments.

**Effect on Root length**

The root length in various amended treatments differed significantly. All treatments registered higher length compared to untreated control. The incorporation of *P. fluorescens*+ carbofuran and *T. viride* + carbofuran gave highest root length (20.66 cm) and (18.50 cm) which was followed by carbofuran (18.33 cm), *P. fluorescens* (17.66 cm) and *T. viride* (17.00 cm) respectively. With respect to percent increase of root length over control, *P. fluorescens* + carbofuran was significantly superior compared to rest of the treatments and recorded maximum root length (48.25%) followed by *T. viride* + carbofuran and carbofuran respectively. However, least root length observed in neem cake (28.93%) and poultry manure (31.92%). (Table.2)

**Effect on Root weight**

**Effect on Fresh weight**

The root weight in various amended treatments differed significantly. All the treatments were recorded significantly better fresh weight over untreated check (4.86 gm). However, *P. fluorescens* + carbofuran was registered maximum weight (7.03 gm) which was on par with *T. viride* + carbofuran (6.94 gm), carbofuran (6.72 gm), *P. fluorescens* (6.62 gm), *T. viride* (6.44 gm), and *P. chlamydosporia* (6.41 gm) respectively. (Table.2)

**Effect on Dry weight**

*P. fluorescens* + carbofuran was registered maximum weight (3.86 gm) which was on par with *T. viride* + carbofuran (3.75 gm), carbofuran (3.70 gm), *P. fluorescens* (3.55 gm) and *T. viride* (3.47 gm), respectively. (Table.2)

**Effect on Root volume**

The root volume in various amended treatments differed significantly. All the treatments were recorded significantly better root volume over untreated check (10.80 ml). However, *P. fluorescens* + carbofuran, registered maximum volume (19.33 ml) which was on par with *T. viride* + carbofuran (18.64 ml), carbofuran (17.86 ml), *P. fluorescens* (17.26 ml) and *T. viride* (17.00 ml), respectively. With respect to percent increase of root length over control, *P. fluorescens* + carbofuran was significantly superior compared to rest of the treatments and recorded maximum root length (44.12%)

followed by *T. viride* + carbofuran and carbofuran respectively. (Table.2)

**Effect on Grain Yield per plot**

*P. fluorescens* + carbofuran was significantly superior compared to rest of the treatments and recorded maximum grain yield (44.1 q/ha) followed by *T. viride* + carbofuran (43.6 q/ha), carbofuran (41.9 q/ha) *P. fluorescens* (41.1 q/ha), and *T. viride* (40.7 q/ha) respectively. (Table.2 and figure.2)

**Effect on Nematode population in soil**

All the treatments significantly superior and recorded least nematode population compared to check. treatments *P. fluorescens* + carbofuran and *T. viride* + carbofuran, were recorded significantly least population (132.67) and (198.00) compared to rest of the treatments. followed by Carbofuran (213.33) *P. fluorescens* (246.00) and *T. viride* (279.67) respectively at the time of harvest (Table.3 and figure.3). with respect to number of galls *P. fluorescens* + Carbofuran was significantly superior recorded least number of galls 10.83 per root system with maximum reduction 82.62%. *T. viride* + carbofuran was found to be next best treatment as it was significantly superior to rest of the treatments 14.70, (76.41%), followed by carbofuran 20.16 (67.65%) and *P. fluorescens* 24.80, (60.21%) respectively. With respect to Number of egg masses/root system treatment combination of *P. fluorescens* + Carbofuran recorded least egg masses per root system with maximum reduction 5.20 (83.17%) followed by *T. viride* + carbofuran 7.46 (75.85%), carbofuran 8.72 (71.77%) and *P. fluorescens* 12.15 (60.67%) respectively. (Table.4 and figure.4). The present results were in consonance with the findings of[13] who reported that the soil application and root dip of *P. fluorescens* or *T. harzianum* + carbofuran was found most effective in increasing yield of rice and suppressed the gall formation, egg mass production and soil population of *M. graminicola.* Application of carbofuran to soil in nursery and main field at the rate of 1Kg a.i. /ha reduced *M. graminicola* by over 90 per cent and resulted in increased yield of about 100%.[14] Further, application of *Pseudomonas flourescens* @ 20 g/m2 was found to be effective in reducing the nematode numbers and increasing the grain yields. [15,16] demonstrated that the adoption of integrated nematode management technology resulted in reducing the nematode population and also increases yields. [17]Integrated nematode management study were conducted in Assam, the pooled data of five years showed that carbofuran treated nursery bed had 100 galls/20 seedlings, *P. fluorescens* and *T. viridae* had 115 galls/20 seedlings and 118 galls/20 seedling. 29.6% and 28.6% yield increased in carbofuran and *P. fluorescens* treated plots.

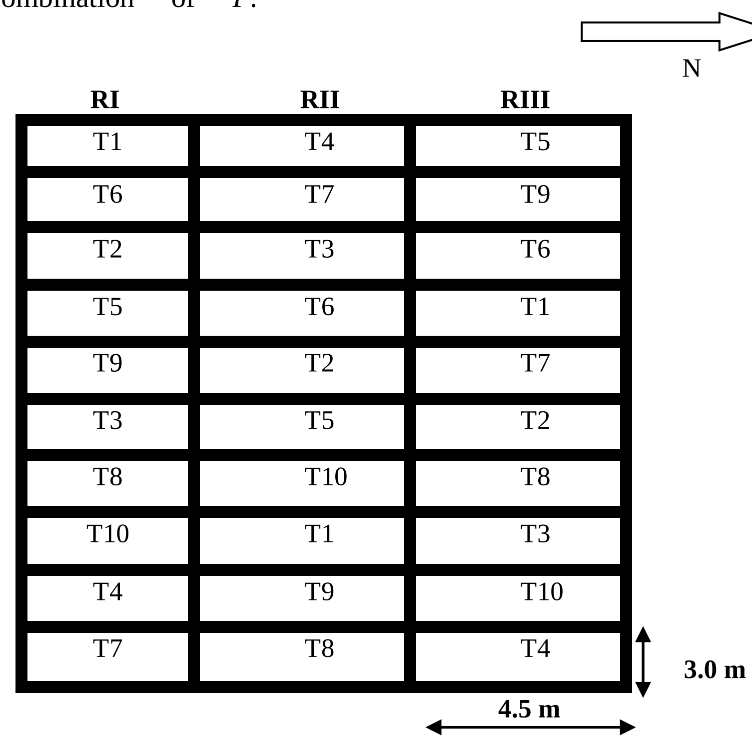


**Fig. 1: Plan of layout of experimental site**

**Table: 1. Effect of bio-agents, organic amendments and nematicide on plant growth parameters of rice infested with *Meloidogyne graminicola***

| Treatments | Plant Height(cm) | | | |
|---|---|---|---|---|
| | **30 DAT** | **60 DAT** | **90 DAT** | **At harvest** |
| T1= *Paceilomyces lilacinus* @20g/m² | 23.00 | 39.36 | 58.66 | 71.00 |
| $T_2$= *Pseudomonas fluorescens* @20g/m² | 24.33 | 43.00 | 64.83 | 76.67 |
| $T_3$ = *Pochonia chlamydosporia* @20g/m² | 23.60 | 41.06 | 59.00 | 74.33 |
| $T_4$ = *Trichoderma viridae* @20g/m² | 23.90 | 42.66 | 63.56 | 75.13 |
| $T_5$ = Carbofuran 3G @16.6g/$m^2$ | 24.66 | 43.83 | 65.80 | 80.50 |
| $T_6$ = Neem cake @100 g/$m^2$ | 21.46 | 37.83 | 53.83 | 69.00 |
| $T_7$ = *Trichoderma viridae* @20g/m² + Carbofuran 3G @16.6g/$m^2$ | 24.66 | 44.00 | 65.93 | 81.26 |
| $T_8$ = *Pseudomonas fluorescens* @20g/m² + Carbofuran 3G @16.6g /$m^2$ | 25.91 | 45.63 | 68.80 | 83.67 |
| $T_9$= Poultry manure @ 100g/$m^2$ | 21.26 | 36.33 | 53.00 | 68.83 |
| $T_{10}$= Untreated control | 15.93 | 30.53 | 42.00 | 59.20 |
| **S.Em ±** | **1.18** | **1.52** | **2.17** | **2.67** |
| **CD (P=0.05)** | **3.52** | **4.51** | **6.46** | **7.93** |

DAT= Days After Transplanting

**Table: 2. Effect of bio-agents, organic amendments and nematicide on growth of rice infested with *M. graminicola***

| Treatments | Root length (cm) | % Increase over control | Root weight | | Root volume (ml) | % Increase over control | Yield (Q / ha) |
|---|---|---|---|---|---|---|---|
| | | | Fresh weight (gm) | Dry weight (gm) | | | |
| T1= *Paceilomyces lilacinus* @ 20g/m² | 16.33 | 34.72 | 6.23 | 3.26 | 15.46 | 30.14 | 39.4 |
| $T_2$= *Pseudomonas fluorescens* @ 20g/m² | 17.66 | 39.63 | 6.62 | 3.55 | 17.26 | 37.42 | 41.1 |
| $T_3$ = *Pochonia chlamydosporia* @20g/m² | 16.66 | 36.60 | 6.41 | 3.36 | 16.60 | 34.93 | 40.0 |
| $T_4$ = *Trichoderma viridae* @20g/m² | 17.00 | 37.29 | 6.44 | 3.47 | 17.00 | 36.29 | 40.7 |
| $T_5$ = Carbofuran 3G @16.6g/$m^2$ | 18.33 | 41.84 | 6.72 | 3.70 | 17.86 | 39.52 | 41.9 |
| $T_6$ = Neem cake @100 g/$m^2$ | 15.00 | 28.93 | 5.84 | 2.90 | 14.33 | 24.63 | 38.9 |
| $T_7$ = *Trichoderma viridae* @20g/m² + Carbofuran 3G @16.6g/$m^2$ | 18.50 | 42.37 | 6.94 | 3.75 | 18.64 | 42.06 | 43.6 |
| $T_8$ = *Pseudomonas fluorescens* @20g/m² + Carbofuran 3G @16.6g /$m^2$ | 20.66 | 48.25 | 7.03 | 3.86 | 19.33 | 44.12 | 44.1 |
| $T_9$= Poultry manure @ 100g/$m^2$ | 15.00 | 31.92 | 5.66 | 2.83 | 14.60 | 26.02 | 37.7 |
| $T_{10}$= Untreated control | 10.66 | - | 4.86 | 2.43 | 10.80 | - | 34.5 |
| **S.Em.±** | **0.71** | **-** | **0.21** | **0.39** | **0.65** | **-** | **0.41** |
| **CD (P=0.05)** | **2.11** | **-** | **0.65** | **1.17** | **1.94** | **-** | **1.21** |

DAT= Days After Transplanting

**Table: 3. Effect of bio agents, organic amendments and nematicide on soil population of *M. graminicola* in main field**

| Treatments | Nematode population / 200cc of soil | | | | |
|---|---|---|---|---|---|
| | **30 DAT** | **60 DAT** | **90 DAT** | **At harvest** | **% Decrease over control at harvest** |
| T1= *Paceilomyces lilacinus* @ 20g/m² | 458.67 | 415.33 | 369.33 | 323.00 | 49.71 |
| $T_2$= *Pseudomonas fluorescens* @ 20g/m² | 426.00 | 365.67 | 308.33 | 246.00 | 61.65 |
| $T_{3=}$ *Pochonia chlamydosporia* @20g/m² | 457.67 | 411.33 | 362.00 | 314.33 | 51.01 |
| $T_{4=}$ *Trichoderma viridae* @20g/m² | 432.33 | 370.00 | 336.00 | 279.67 | 56.46 |
| $T_{5=}$ Carbofuran 3G @16.6g/m² | 401.00 | 337.67 | 269.33 | 213.33 | 66.78 |
| $T_{6=}$ Neem cake @100 g/m² | 470.00 | 432.67 | 386.67 | 341.33 | 46.86 |
| $T_{7=}$ *Trichoderma viridae* @20g/m² + Carbofuran 3G @16.6g/m² | 391.00 | 326.67 | 261.33 | 198.00 | 69.17 |
| $T_{8=}$ *Pseudomonas fluorescens* @20g/m² + Carbofuran 3G @16.6g /m² | 373.67 | 287.33 | 216.00 | 132.67 | 79.34 |
| $T_{9=}$ Poultry manure @ 100g/m² | 488.00 | 453.00 | 404.33 | 358.67 | 44.16 |
| $T_{10=}$ Untreated control | 495.67 | 538.00 | 585.00 | 642.33 | - |
| **S.Em.±** | **24.13** | **23.79** | **22.25** | **24.48** | **-** |
| **CD (P=0.05)** | **71.70** | **70.71** | **66.11** | **72.75** | **-** |

**DAT=** Days After Transplanting
**Average INP=550$J_2$ / Plot**

**Table 4: Effect of bio-agents, organic amendments and nematicide on reproduction of *M. graminicola* in main field**

| **Treatments** | **No. of galls per root system** | **% Decrease Over Control** | **No. of egg masses/ root system** | **% Decrease Over Control** |
|---|---|---|---|---|
| T1= *Paceilomyces lilacinus* 20g/m² | 42.00 | 32.61 | 20.76 | 32.81 |
| $T_2$= *Pseudomonas fluorescens* @20g/m² | 24.80 | 60.21 | 12.15 | 60.67 |
| $T_{3=}$ *Pochonia chlamydosporia*@20g/m² | 41.22 | 33.86 | 19.53 | 36.79 |
| $T_{4=}$ *Trichoderma viridae* @20g/m² | 32.76 | 47.44 | 13.20 | 57.28 |
| $T_{5=}$ Carbofuran 3G @16.6g/m² | 20.16 | 67.65 | 8.72 | 71.77 |
| $T_{6=}$ Neem cake @100 g/m² | 46.92 | 24.72 | 20.80 | 32.24 |
| $T_{7=}$ *Trichoderma viridae* @20g/m² + Carbofuran 3G @16.6g/m² | 14.70 | 76.41 | 7.46 | 75.85 |
| $T_{8=}$ *Pseudomonas fluorescens* @20g/m² + Carbofuran 3G @16.6g/m² | 10.83 | 82.62 | 5.20 | 83.17 |
| $T_{9=}$ Poultry manure @ 100g/m² | 43.23 | 30.64 | 21.66 | 29.90 |
| $T_{10=}$ Untreated control | 62.33 | - | 30.90 | - |
| **S.Em.±** | **1.55** | **-** | **1.55** | **-** |
| **CD (P=0.05)** | **4.61** | **-** | **4.62** | **-** |

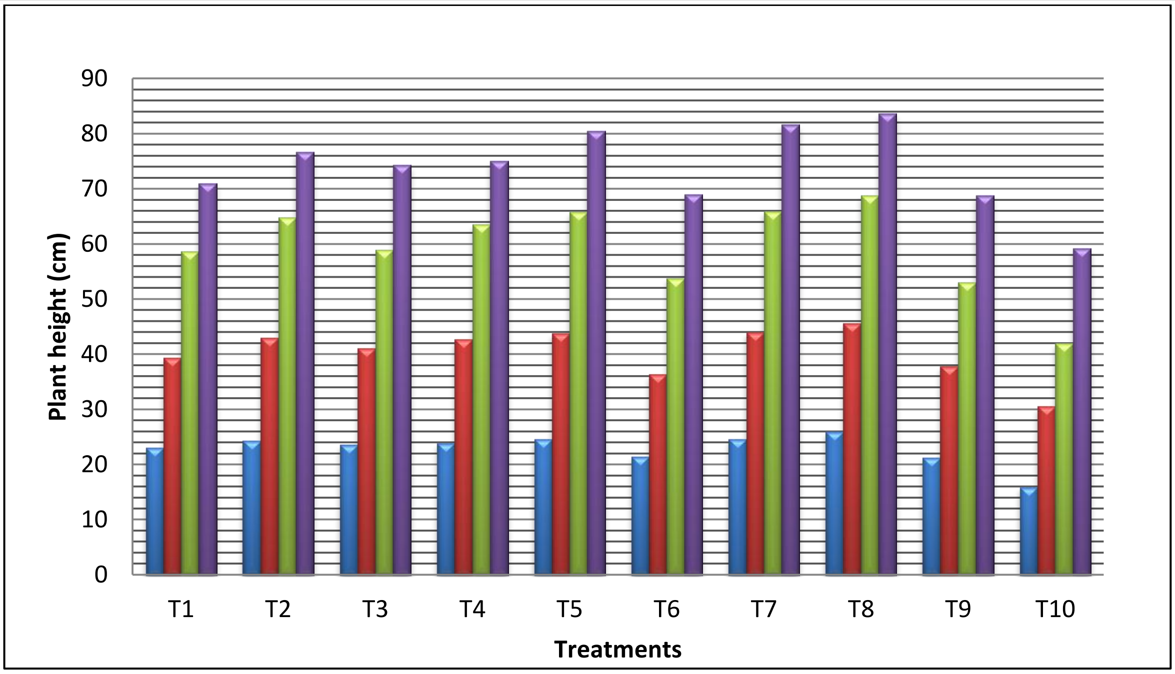


**Fig: 1: Effect of bio-agents, organic amendments and nematicide on plant growth parameters of rice infested with *Meloidogyne graminicola***

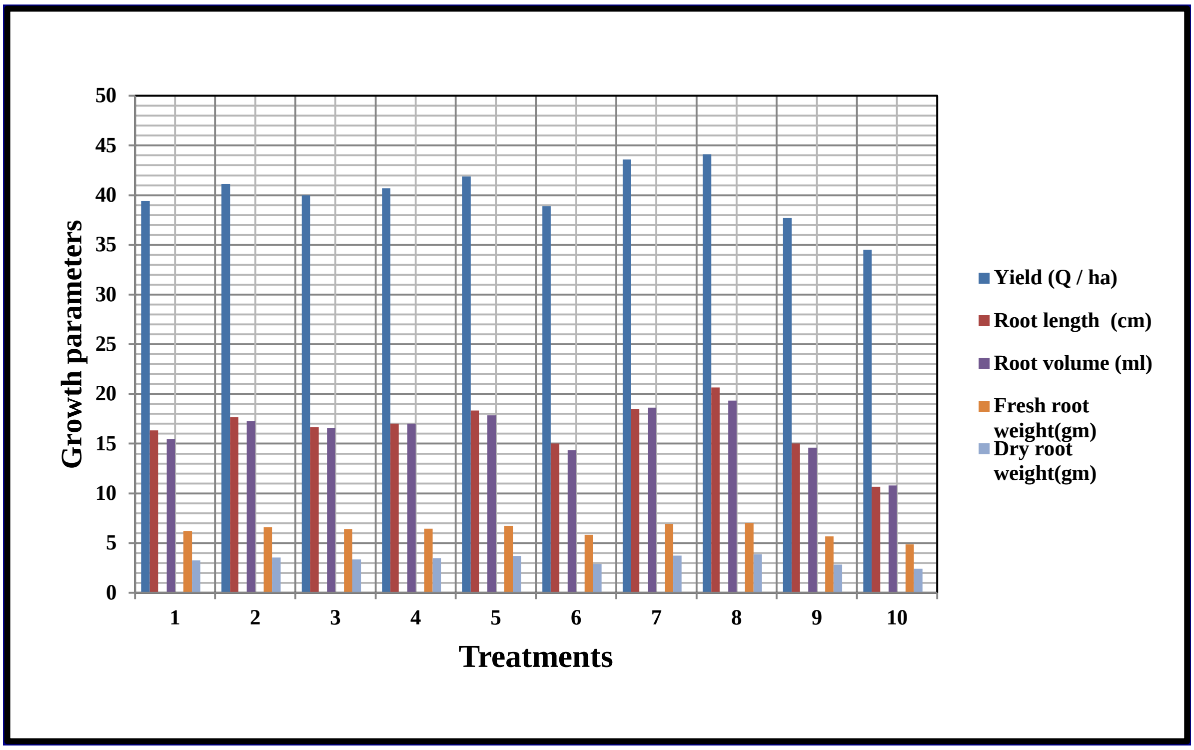


**Fig. 2: Effect of bio-agents, organic amendments and nematicide on growth of rice infested with *M. graminicola***

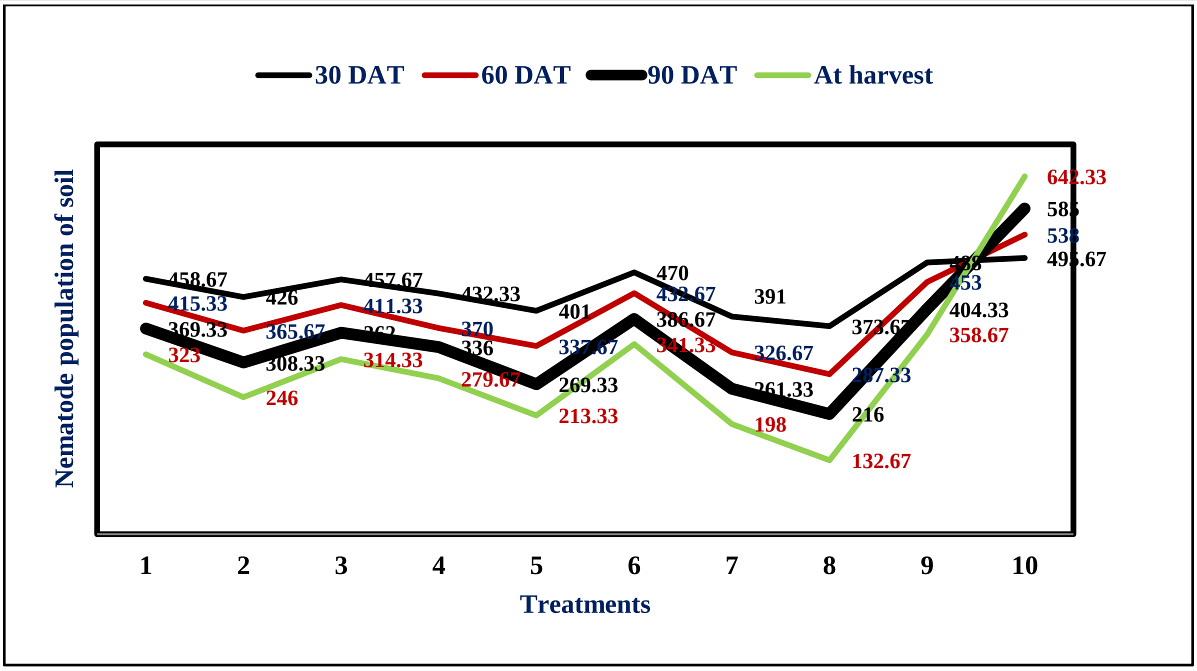


**Fig. 3: Effect of bio agents, organic amendments and nematicide on soil population of *M. graminicola* in main field**

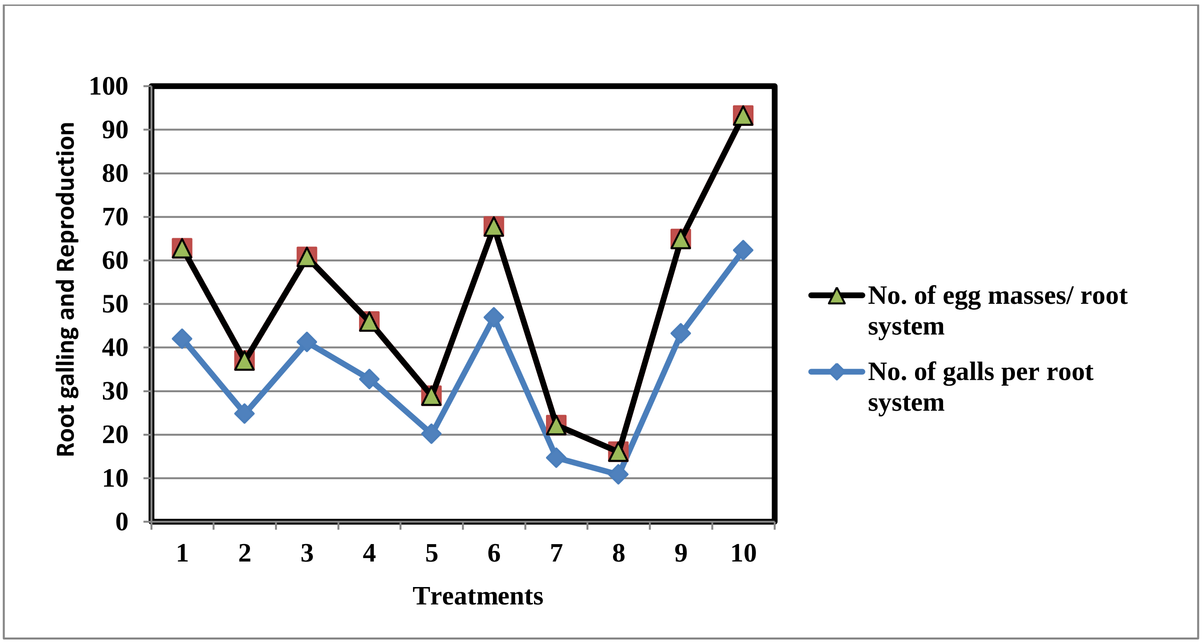


**Fig.4: Effect of bio-agents, organic amendments and nematicide on reproduction of *M. graminicola* in main field**

## CONCLUSION

The present study implies that treatment combination of *Pseudomonas fluorescens* + Carbofuran 3G play vital role in managing the rice root-knot nematode it is may be due to combined effect of bio agent and nematicideand also production of phenols and defensive enzymes when treated with *P. fluorescens* in response to invasion by *M. graminicola*. results in reduction of population density of nematodes.

**Acknowledgements**

This research is a part of the M.Sc. dissertation of first author that was funded by Department of Plant Pathology, College of Agriculture,

University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka.

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