Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.2506

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **5 (1):** 687-693 (2017)

Research Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Studies on Pathogenicity of *Meloidogyne graminicola* in Different Soil types on Scented and Non-Scented Rice

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Received: 24.01.2017 | Revised: 5.02.2017 | Accepted: 7.02.2017

ABSTRACT

To study the comparative effect of M. graminicola on both types of rice, i.e., scented (var. Pusa 1121) and non-scented rice (PR 114), a screen house study was conducted to see the relationship between inoculum density of Meloidogyne graminicola, growth of rice plants and development of the nematode was carried out in three different types of soil (clay loam, sandy loam and loamy sand. Different inoculum levels used were 0 (non-inoculated check), 10, 100, 1000 and 10000 j_2/kg soil. Plant growth parameters decreased significantly as inoculum levels increased from 100-10000 j_2 irrespective of soil types indicating 100 j_2 as damaging threshold level of M. graminicola on both types of rice. Plant growth was at par in 10 j_2 and non inoculated check as compared to other inoculums levels. With each increase in inoculum levels from 10-1000 $j_{2,}$ nematode multiplication and reproduction was increased but decreased abruptly at 10000 j_2. Maximum and significantly highest multiplication and reproduction was observed in 1000 j_2 of M. graminicola.

Key words: *Meloidogyne graminicola, scented rice, non-scented rice, pathogenicity, inoculum levels*

INTRODUCTION

Rice (*Oryza sativa*) is one of the most important food crops in the world. India is the largest producer and consumer of rice in the world. The rice-wheat cropping system (RWCS) is the backbone of India's food security. Rice is most susceptible to root-knot nematodes and is attacked by *Meloidogne incognita*, *M. graminicola*, *M. triticoryzae* and other species[2]. Amongst these species, *M. graminicola* is a primary pest of rice and poses a substantial threat to rice cultivation in Southeast Asia where around 90 % of the world rice is grown and consumed[1], causing yield losses of 16-32% in rainfed and upland rice in India[7].

The major cause for such high incidence of this nematode infestation is attributed to the presence of light textured soil, the non-availability of ample water and transplantation of infected seedlings. Formation of terminal, hook shaped or spiral galls are the characteristic symptoms by this nematode[3]. As rice is being grown in various soil types prevalent in different agro-climatic zones of India, so such studies have to be carried out in different textured soils.

Cite this article: Kumar, V., Verma, K. K. and Kumar, A., Studies on Pathogenicity of *Meloidogyne graminicola* in Different Soil types on Scented and Non-Scented Rice, *Int. J. Pure App. Biosci.* **5(1):** 687-693 (2017). doi: http://dx.doi.org/10.18782/2320-7051.2506

MATERIALS AND METHODS

Experiments were conducted in screen house to study the pathogenicity of *M. graminicola* on rice in the of Department of Nematology, CCS HAU, Hisar during kharif, 2014-15. The culture of root-knot nematode, *M. graminicola* was maintained on rice plants in the pots. For inoculation purposes, infested plants were uprooted carefully, washed in running tap water and eggs and j_2 were collected in Petri dishes containing distilled water. The experiment was conducted using the variety namely scented (var. Pusa 1121) and non-scented rice (PR 114). Seeds of the above variety were soaked in tap water for 24 hours and the sprouted seeds were sown in pots having sterilized soil,i.e., clay loam, sandy loam and loamy sand soil by using a series of different inoculum levels such as 0 (non-inoculated check), 10, 100, 1000 and 10000 j_2/kg soil on basmati (var. Pusa 1121) and non-basmati rice (var. PR 114).

After four days of sowing, freshly hatched j_2 of *M. graminicola* were inoculated in seedlings grown under three different types of soil in a series mentioned above. The juveniles were inoculated as per treatment schedule. Each treatment was replicated three times and the statistical design was Factorial CRD. Forty days after inoculation, the following observations were recorded: plant growth characteristics (shoot length, fresh shoot weight (wt), dry shoot wt, fresh and dry root wt and also on nematode multiplication and reproduction such as number of galls, number of eggs/plant and number of j_2 in the soil.

RESULTS AND DISCUSSION

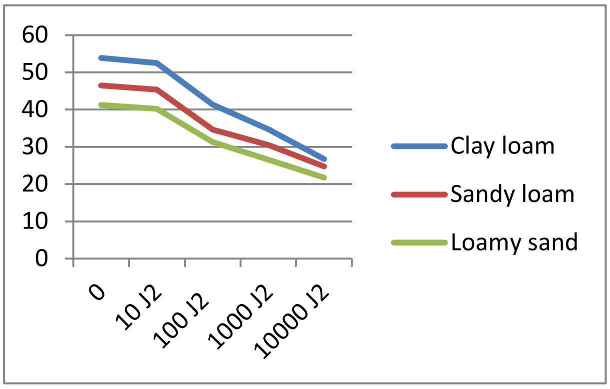
In scented rice, the data revealed that maximum and significantly highest plant growth was observed in clay loam soil as compared to sandy loam and loamy sand irrespective of inoculum levels. As far as effect of different inoculum levels is concerned, the significant reduction in shoot and root parameters started at 100 j_2/kg soil while the plant growth at 10 j_2 was statistically at par with non-inoculated check (0 j_2) which had maximum plant growth. Plant growth parameters were decreased as inoculum levels increased from 100-10000 j_2 (Fig. 1). The interaction between soil type and inoculum levels was significant in shoot length, fresh shoot weight and fresh root weight. Plant growth parameters were maximum and significantly higher in interaction of clay loam soil at non-inoculated check, which was statistically at par with 10 j_2.

Nematode reproduction and multiplication was more in loamy sand as compared to sandy loam and clay loam. At each increase in inoculum levels from 10-1000 j_2/kg soil, there was corresponding increase in nematode reproduction upto 1000 j_2 but decreased significantly at highest inoculum levels of 10000 j_2/kg soil. In case of interaction between soil types and inoculum levels, number of galls/plant and final nematode population in soil was significant. Significantly highest nematode parameters were observed at 1000 j_2 in loamy sand followed by sandy loam and clay loam (Table 1).

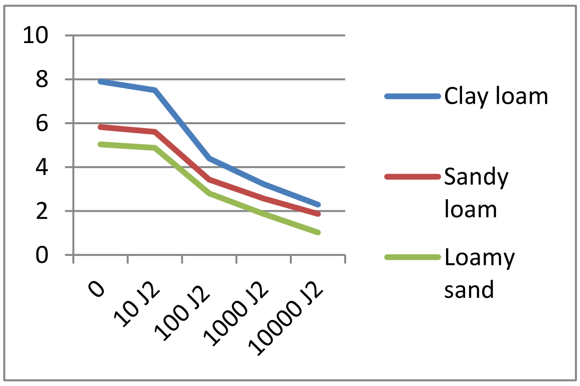
In non-scented rice, the data revealed that minimum and significantly lowest plant growth was observed in loamy sand soil as compared to sandy loam and clay loam irrespective of inoculum levels. Significant reduction in growth parameters was found at 100 j_2/kg soil, while the plant growth at 10 j_2 was statistically at par with non-inoculated check. Minimum plant growth was observed at 10000 followed by 1000 and 100 j_2. Plant growth parameters were decreased as inoculum levels increased from 10-10000 j_2 (Fig. 2). The interaction between soil type and inoculum levels was significant in dry shoot weight, fresh root weight and dry root.

Nematode reproduction and multiplication was more in loamy sand as compared to sandy loam and clay loam. As inoculum levels increased from 10-1000 j_2/kg soil, nematode reproduction and multiplication was increased correspondingly but it decreased significantly at highest inoculum levels of 10000 j_2/kg soil. The interaction between soil types and inoculum levels was however non-significant. Significantly minimum reproduction and multiplication was obtained in clay loam and maximum in loamy sand at 10 j_2 (Table 2).

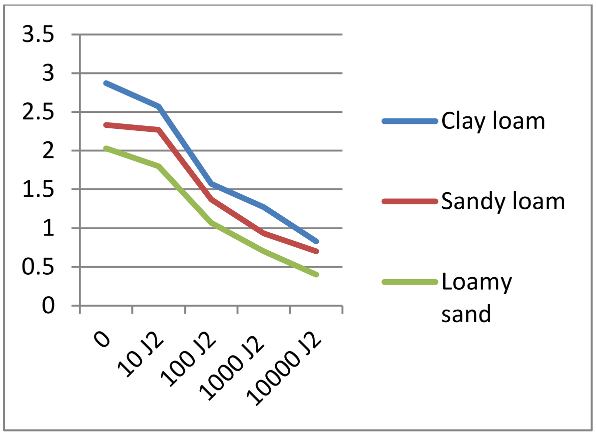
The highest growth of rice plants was observed in clay loam followed by sandy loam and loamy sand in both types of rice i.e. scented (var. Pusa 1121) and non-scented (var. PR 114) irrespective of the inoculum levels indicating the preference of rice to grow well in clay loam because of high clay content of 39.0 per cent in clay loam as compared to 11.0 per cent in sandy loam and 8.3 per cent in loamy sand (as per soil analysis).



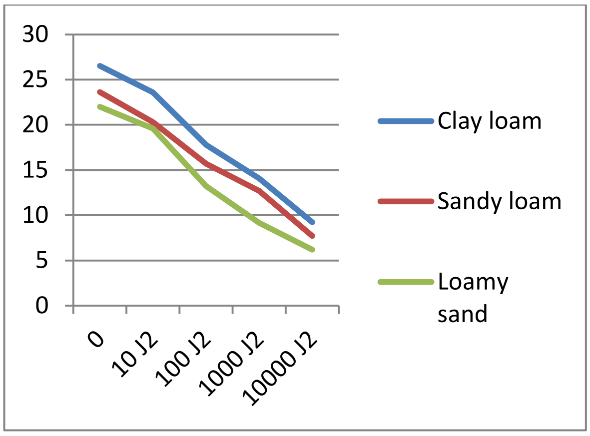
Shoot length (cm)



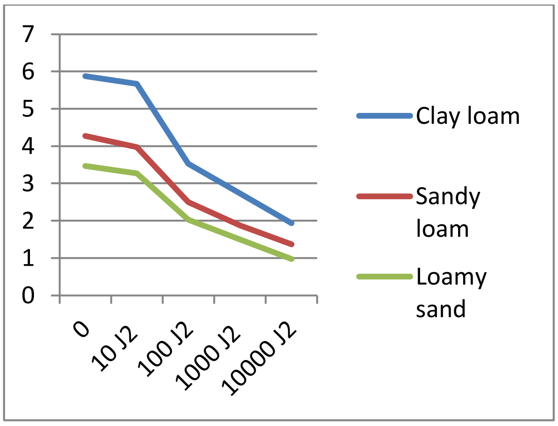
Fresh shoot weight (g)



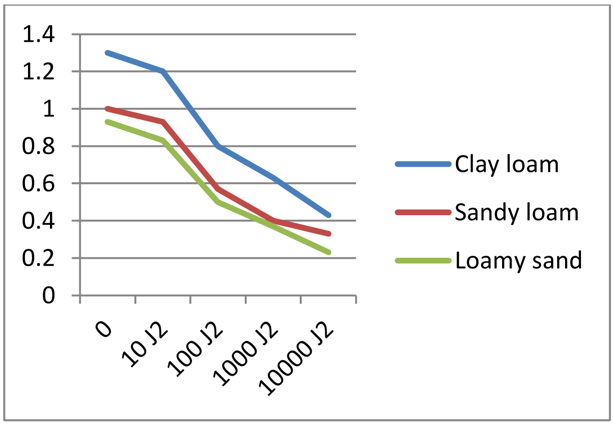
Dry shoot weight (g)



Root length (cm)



Fresh root weight (g)



Dry root weight (g)

Fig. 1: Effect of different inoculum levels of *M. graminicola* on plant growth parameters of scented rice (var. Pusa 1121) in different soil types

Table 1: Effect of inoculum levels on reproduction and multiplication of *M. graminicola* in scented rice (var. Pusa 1121) in different soil types (Average of three replications)

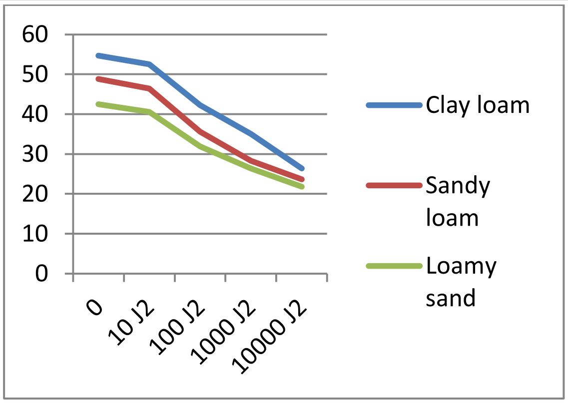
Inoculum levels (j_2/kg soil)	Number of galls/plant Soil types			Mean	Number of eggs/plant Soil types			Mean	Final soil population (j_2)/kg soil Soil types			Mean
	Clay loam	**Sandy Loam**	**Loamy Sand**		**Clay loam**	**Sandy loam**	**Loamy sand**		**Clay loam**	**Sandy Loam**	**Loamy Sand**	
10	15.0 (4.0)	22.0 (4.8)	25.0 (5.1)	20.7 (4.6)	455.0 (21.3)	655.0 (25.5)	705.0 (26.4)	605.0 (24.4)	45.0 (6.7)	60.0 (7.8)	78.0 (8.9)	61.0 (7.8)
100	79.0 (8.9)	122.0 (11.1)	145.0 (12.1)	115.3 (10.7)	2070.0 (45.4)	3280.0 (57.1)	4050.0 (63.3)	3133.3 (55.3)	245.0 (15.7)	292.0 (17.1)	350.0 (18.7)	295.7 (17.1)
1000	117.0 (10.8)	168.0 (13.0)	192.0 (13.9)	159.0 (12.6)	3825.0 (61.8)	5290.0 (72.7)	6000.0 (77.5)	5038.0 (70.7)	690.0 (26.3)	970.0 (31.1)	1150.0 (33.9)	932.7 (30.4)
10000	63.0 (8.0)	70.0 (8.4)	71.0 (8.5)	68.0 (8.3)	1585.0 (39.8)	1740.0 (41.5)	2010.0 (44.8)	1778.3 (42.0)	117.0 (10.8)	154.0 (12.4)	175.0 (13.9)	148.6 (12.1)
Mean	68.5 (7.9)	95.5 (9.3)	108.3 (9.9)		1983.0 (42.1)	2741.3 (49.2)	3191.0 (53.0)		274.3 (14.9)	369.0 (17.1)	438.0 (18.7)	
C.D. at 5 per cent												
Soil types		(0.6)				(3.4)				(1.1)		
Inoculum levels		(0.7)				(3.9)				(1.3)		
Interaction (Soil types v/s inoculum levels)		(1.2)				N.S.				(2.2)		

Since the observations recorded were nil in non-inoculated (0 j_2) check, so this treatment is not depicted in the Table
Figures in parentheses are √ n transformed value

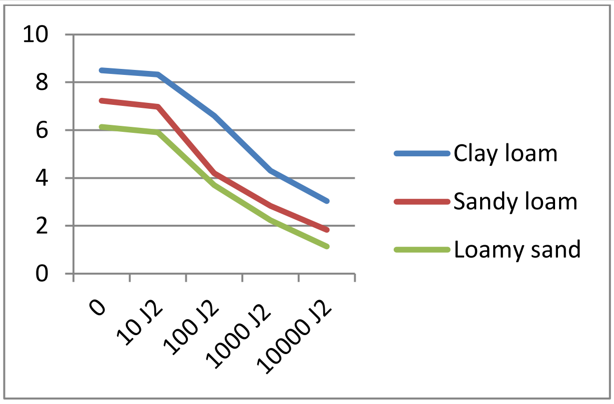
These results are in conformity with those of Prot and Matias[8] who also observed higher growth of rice plants in clay loam soil. The amount of sand present in all types of soil in the present investigation, is also contributing for the lower growth of plants. Loamy sand had 82.1 per cent sand which was least favored by rice to grow well followed by sandy loam and clay loam which had sand content of 74.0 and 36.0 per cent, respectively. So this difference in the growth of plants may be attributed to difference in soil texture, water holding capacity and nutrient availability of their soil. In its contrast, the multiplication and reproduction of *M. graminicola* was significantly highest in loamy sand followed by sandy loam and least in clay loam. This reverse trend of lowest plant growth in loamy sand but highest development of nematode speaks well of the amount of sand content which was highest in loamy sand followed by sandy loam and clay loam. Higher amount of sand content is favorable for this nematode in particular and other plant parasitic nematodes in general.

As it is well established fact that coarse textured soils having high sand content had more pore space (because of the increase in the diameter of soil particles) for the movement and developments of the nematode. These results are in conformity with those of Rao and Israel[10] who observed that coarse and medium soils with particle size above 0.053 mm in diameter allowed free movement of infective larvae and invasion into roots of the rice plant. In present study, clay loam soil was least favoured by this nematode for its multiplication. The same trend was observed by Rao and Israel[10], Prot and Matias[8] and Pokharel[4]. Rao and Israel[10] correlated the nematode development with sand content of soil. With the increase in sand content of the soil, there was an increase in number of galls, number of eggs per plant and final soil population of the nematode, showing thereby the relationship between the sand content and high activity of the nematode.

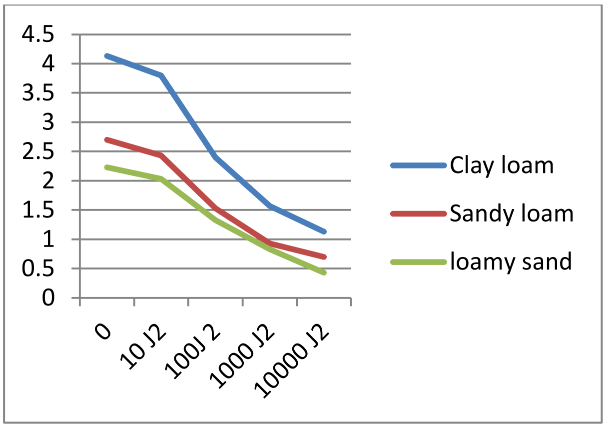
The difference in the growth of scented and non-scented rice varieties in same soil types may be due to the difference of growth pattern of both type of rice. The growth of non-scented rice (var. PR 114) was slightly more than that of scented rice (var. Pusa 1121) as it clear from the data of plant growth parameter of non-inoculated treatments. The multiplication and reproduction of this nematode was more in scented rice as compared to non-scented rice which may be attributed to the reaction of the variety towards *M. graminicola*.



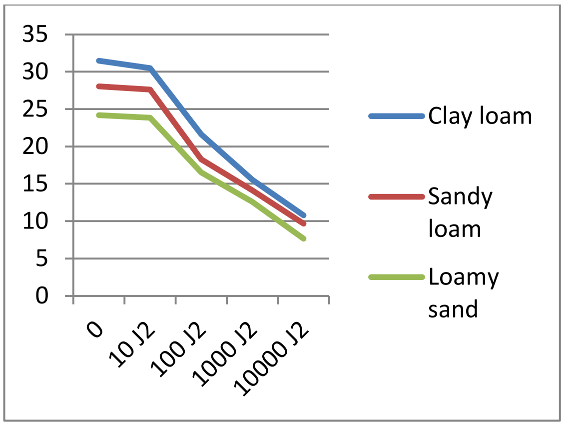
Shoot length (cm)



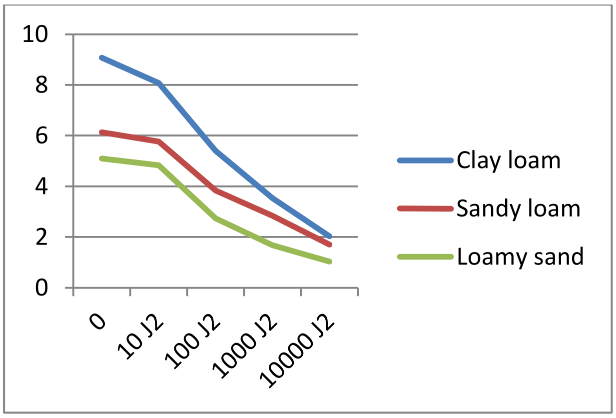
Fresh shoot weight (g)



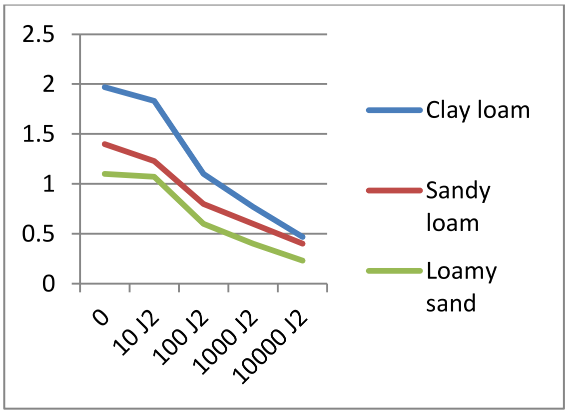
Dry shoot weight (g)



Root length (cm)



Fresh root weight (g)



Dry root weight (g)

Fig. 2: Effect of different inoculum levels of *M. graminicola* on plant growth parameters of non- scented rice (var. PR 114) in different soil types

Table 2: Effect of inoculum levels on reproduction and multiplication of *M. graminicola* in non-scented rice (var. PR 114) in different soil types (Average of three replications)

Inoculum levels (j_2/kg soil)	Number of galls/plant Soil types			Mean	Number of eggs/plant Soil types			Mean	Final soil population (j_2)/kg soil Soil types			Mean
	Clay Loam	Sandy loam	Loamy sand		Clay loam	Sandy loam	Loamy sand		Clay loam	Sandy Loam	Loamy sand	
10	10.0 (3.3)	17.0 (4.2)	21.0 (4.7)	16.0 (4.1)	315.0 (17.7)	490.0 (21.9)	620.0 (24.9)	475.0 (21.5)	38.0 (6.2)	50.0 (7.1)	85.0 (9.3)	57.7 (7.5)
100	55.0 (7.6)	80.0 (9.0)	103.0 (10.2)	79.3 (8.9)	1555.0 (39.3)	2145.0 (46.1)	2800.0 (52.8)	2166.7 (46.0)	205.0 (14.3)	280.0 (16.7)	310.0 (17.6)	265.0 (16.2)
1000	90.0 (9.6)	124.0 (11.2)	145.0 (12.1)	119.7 (11.0)	2700.0 (51.9)	3850.0 (62.0)	4320.0 (65.5)	3623.3 (59.8)	625.0 (25.0)	810.0 (28.4)	995.0 (31.5)	810.0 (28.3)
10000	40.0 (6.4)	48.0 (7.0)	61.0 (7.9)	49.7 (7.1)	1185.0 (34.3)	1335.0 (36.5)	1555.0 (39.3)	1358.3 (36.9)	110.0 (10.5)	160.0 (12.7)	190.0 (13.8)	155.3 (12.3)
Mean	48.8 (6.7)	67.3 (7.8)	82.5 (8.7)		1438.7 (35.8)	1995.0 (41.6)	2323.0 (45.6)		244.5 (14.0)	325.0 (16.2)	395.0 (18.0)	
C.D. at 5 per cent												
Soil types		(0.5)				(3.7)				(1.1)		
Inoculum levels		(0.6)				(4.3)				(1.3)		
Interaction (Soil types v/s inoculum levels)		N.S.				N.S.				N.S.		

Since the observations recorded were nil in non-inoculated (0 j_2) check, so this treatment is not depicted in the Table
Figures in parentheses are √ n transformed values

The biochemistry and physiology of variety Pusa 1121 may be more favourable to the nematode as compared to variety PR 114, which is less susceptible though the nematode multiplied well in both the varieties.The role of the abiotic factors particularly temperature prevailing at the time of infestation in also considered as factor for difference in the varietal response. Rice is particularly sensitive to temperature and even various cultivars within rice differ in their root production and extension responses to temperature which in turn will affect their response to nematode attack, irrespective of the soil types.

Plant growth parameters having 10 j_2/kg soil had statistically at par growth with non-inoculated check (no nematode inoculation), significant reduction in growth parameters was observed from inoculum level of 100 j_2/kg soil onwards. It can be inferred that inoculum level of 100 j_2/kg soil proved to be pathogenic due to reduced growth of rice plants at this level. This low inoculum level of 100 j_2/kg soil speaks of nematode to be very severe and pathogenic on both type of rice in contrast to other species of root-knot nematode in which 1000 j_2/kg soil is considered to be threshold level. The short life cycle duration, high reproduction potential, many generations in a single crop season are the factors which are considered to be important for the severity of this nematode even at low inoculum level. Poudyal *et al.*,[5] also concluded that the response of plant to nematode invasion will depend on the status of the host and the nematode population. Nematode effects on plant growth and yield are generally proportional to the numbers of infective nematode per unit of soil at planting. There is a population density below which no loss in plant growth and yield occurs. These results are in conformity with findings of Prasad *et al.*, [6] and Poudyal *et al.*, [5] who observed 200 and 125 j_2/kg soil to be pathogenic level.

There was significant increase in nematode multiplication with corresponding increase in inoculum levels starting from 10-1000 j_2/kg soil in both type of rice but the results were more pronounced in var. Pusa 1121 showing it to be more susceptible as compared to var. PR 114. The highest multiplication was observed at 1000 j_2/kg soil which reduced drastically at 10000 j_2 levels in both types of rice. The probable reason for this reversal was the high density of the nematode in a limited space in soil. Occurring of these conditions might have competition for space, nutrition and other requirement of the nematodes as it is clear from debilitation of roots having 10000 j_2 in the form of lowest root growth. Due to sharp decline in the growth parameters of the roots at 10000 j_2 level, there might be mortality of nematodes due to overcrowding. Rao and Israel[9] also observed the high rate of reproduction of *M. graminicola* in rice at low levels of inocula, could possibly be due to the positive factors like abundance of food, lack of competition, ability of the host to support these levels of population, the negative density factor like crowding of endoparasites in the roots.

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