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Effect of soil organic matter content and soil texture on reproduction of *Meloidogyne graminicola* on rice

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Abstract

Effects of soil organic matter content, pH and soil texture on the reproduction of *Meloidogyne graminicola* in scented and non-scented rice were evaluated in pot experiments from June to September, 2014. Sterilized soil was inoculated with second stage juveniles (j_2) of M. graminicola to give 0, 10, 100, 1000 and 10000 j_2/kg of soil. Three types of soil texture classes were observed such as clay loam, sandy loam and loamy sand and the highest reproduction was observed in loamy sand followed by sandy loam and least in clay loam irrespective of inoculum levels. Maximum reproduction was found in loamy sand at inoculum level of 10 j_2/kg soil and minimum in clay loam soil at 10000 j_2/kg in both types of rice. Population densities of *M. graminicola* were inversely related to the percentage of sand, silt, and clay. The highest mean soils as well as root population numbers of *M. graminicola* were observed in loamy sand with organic matter contents of 4% as compared to sandy loam and clay loam.

Keywords: Rice, *Meloidogyne graminicola,* soil type, pH, organic carbon, reproduction

Introduction

Rice (*Oryza sativa* L.) is an important cereal crop of India and is the second most staple food crop of the world next to wheat and staple food for two thirds of world's population [1]. In India the area under rice cultivation is 43.8 million hectare with total production of rice is 104.3 million tonnes [5]. It is affected by several abiotic and biotic stresses, of which plant parasitic nematodes (PPNs) constitute an important component. Among them, rice root-knot nematode (*Meloidogyne graminicola*) has very wide distribution particularly in the rice growing areas of the world. It is not only a serious problem in nurseries and upland rice but also found to be widespread in the deep water and irrigated rice in many states of India [13, 9, 8]. The major factor responsible for such high incidence of nematode infestation in these areas was the presence of light-textured soil and non-availability of ample irrigation water. The rice root-knot nematode has been reported as a pest of rice causing 17-30 % yield losses due to poorly filled kernels [7].

PPNs are soil-borne pathogens whose growth and reproduction are influenced by the soil conditions. The ecological conditions (edaphic factor) suitable for the cultivation of rice crop are very well congenial for the multiplication of nematodes infecting rice. Among these soil conditions, soil texture, estimated by the relative quantity of sand, silt and clay particles in a soil, is an important component that determines soil compactness and thus availability of aeration and moisture, which is explored as a basis for management of PPNs within a field [10]. Therefore, the present study we tried to define the effects of soil organic matter and texture on the reproduction of *M. graminicola* in scented and non-scented rice.

Material and Methods

The present experiment was conducted in the screen house of the Department of Nematology, CCS HAU, Hisar during June-September, 2014. Two varieties Pusa 1121 (scented) and PR 114 (non-scented) were used to study the effect of the soil organic matter content and soil texture on the reproduction of rice root-knot nematode (*M. graminicola*). Three types of soil viz., sandy loam, loamy sand and clay loam was collected from different sites was sterilized in autoclave at 15 lbs pressure with 121±1 ^{O}C for one hour (Table 1). Each soil type was then allowed to dry for one day and then filled in 15 cm diameter earthen pots (one kg capacity). The physico-chemical properties and texture of various types of soils were got analysed by Department of Soil Science, CCS HAU, Hisar which are as follow:

Table 1: Texture, composition and other characteristics of different soils.

Soil type	Percentage of			pH	E.C. (dSm^{-1})	Organic carbon (%)	Availability (kg/ha)	
	Sand	Silt	Clay				Phosphorus	Potash
Clay loam	36.0	25.0	39.0	8.3	0.61	0.49	9	270
Loamy sand	82.1	9.6	8.3	7.9	0.32	0.39	12	300
Sandy loam	74.0	15.0	11.0	7.9	0.29	0.75	22	342

The *M. graminicola* population used in this experiment was originally recovered from rice roots grown in soil collected from a *M. graminicola* infested field at CCS HAU Hisar. Seeds of the above varieties were soaked in tap water for 24 h and the sprouted seeds were sown in the pots filled with different soil types. Four inoculums levels viz. 10, 100, 1000 and 10000 j_2/kg soil were kept. Each treatment was replicated three times. One set of treatments without nematodes was also maintained. After four days of sowing, freshly hatched j_2 of *M. graminicola* were inoculated in seedlings. Inoculations of freshly hatched juveniles were done through holes made around each seedling. The experiment was terminated 40 days after inoculation and observations were recorded on nematode multiplication such as number of eggs/plant and number of j_2/kg of soil. For total number of nematode population, the plant roots were washed thoroughly under a gentle stress of water and soil samples were processed by modified Cobb's sieving and decanting method followed by modified Baermann's funnel method [18]. The reproduction factor was calculated from total nematode population (root+soil) in relation to the initial inoculum levels.

Reproduction factor (RF) = Pf/ Pi
Where, Pi = Initial population
Pf = Final population

Statistical analysis
The data obtained in the experiment was analysed statistically design was Factorial CRD.

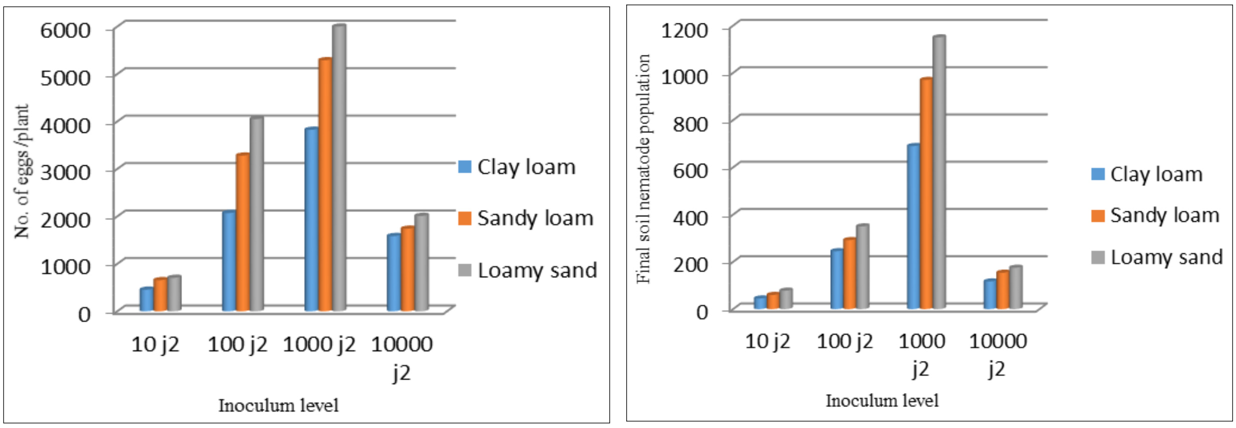
Results and discussion
The present study was undertaken to investigate the effects of soil type, particle size, pH, and organic matter content on the reproduction of the *M. graminicola* in rice. Among the different soils type (clay loam, sandy loam and loamy sand) the mean numbers of soil and root population was highest in loamy sand soil at 1000 j_2 and lowest in clay loam soil at 10 j_2 in both types of rice i.e scented and non-scented rice. Perusal of data in Fig. (-1 and -2) indicated that nematode reproduction and multiplication was more in loamy sand as compared to sandy loam and clay loam. In the current study the highest numbers of *M. graminicola* were observed in lighter soils (loamy sand) with clay (8.3 %), sand (82.1 %) and silt (9.6 %) and lowest in clay loam with clay (36.0 %), sand (25.0 %) and silt (39.0 %). This shows that the *M. graminicola* tends to prefer light to medium soils. As sand content in the soil increased from 36.0 (clay loam) to 82.1 (loamy sand), nematode reproduction and multiplication was increased correspondingly. With the increase in sand content of the soil, there was an increase in number of eggs per plant and final soil population of the nematode, showing there by the relationship between the sand content and high activity of the nematode.

These results are in conformity with those of Rao and Israel [15] who observed that coarse and medium soils with particles size above 0.053 mm in diameter and sandy soils allowed free movement of infective larvae and invasion into roots of the rice plant. The same trend was observed by Rao and Israel [15] Prot and Matias [14] and Pokharel [12]. Rao and Israel [15] correlated the nematode development with sand content of soil. They further observed that in fine soils, migration of larvae was 13.5 per cent whereas in coarse textured soils, the migration of larvae was 76.1 per cent while in medium soil, larval migration was 47.0 per cent.

In present study, clay loam soil was least favoured by this nematode for its multiplication and reproduction. These results agree with the general aspects that the agricultural importance of the root-knot nematodes is associated with sandy soils and that crop damages associated with root-knot nematode infections are highly reflective of sandy soils and sandy patches within fields [21]. Infestations of *M. incognita* and *M. hapla* occur more frequently in sandy loam soils than in clay soils [17]. However, our findings are supported by Wallace [23] who suggested that some *Pratylenchus* species are associated with lighter sandy soil. Generally light sandy soils are more favourable to large populations of nematodes than heavy clay soils owing to more adequate aeration provided in soils consisting of coarse particles, but cause more nematode damages on plants that suffer from water stress due to easy drainage of water in coarse particulate sandy soils[4]. As it is well established fact that coarse textured soils having high sand content had more pore space for the movement and developments of the nematode.

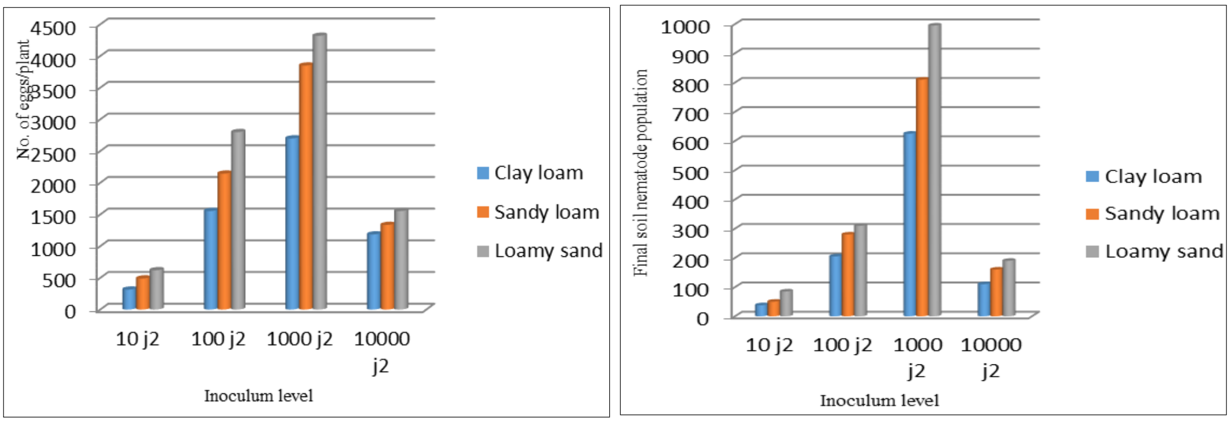
On the other hand, organic matter contents varied from 0.39 to 0.75 %. The highest soils as well as root population numbers of *M. graminicola* were observed in loamy sand with organic matter contents of 4 % as compared to sandy loam and clay loam (Fig. -1 and -2). However, the population number of was higher in soils with low value of organic carbon i. e. loamy sand. The same trend was observed by Gnanapragasam and Sivapalan [6] who observed that the population of tea root lesion nematodes was higher in soils of 3% organic matter content than in soils with 10 % of organic matter. Other studies found an increase of PPNs following the addition of soil organic matter [20]. Many studies have shown that addition of organic matter in the form of compost or green manures can reduce population's nematodes [22].

The pH itself is a complex factor which decreases with soil carbon dioxide released from all organisms including *M. graminicola*. The pH value (7.9 to 8.3) of soil may, however, be suitable for high population of *M. graminicola* in the present studies. The present studies was conformity with those of Swarup and Dasgupta [19] who reported that the root knot nematodes can survive, hatch and reproduce at pH 4.0-8.0, even 10.0. It is evident that numbers of PPNs vary with soil texture as well as pH [11, 16].



(A) (B)

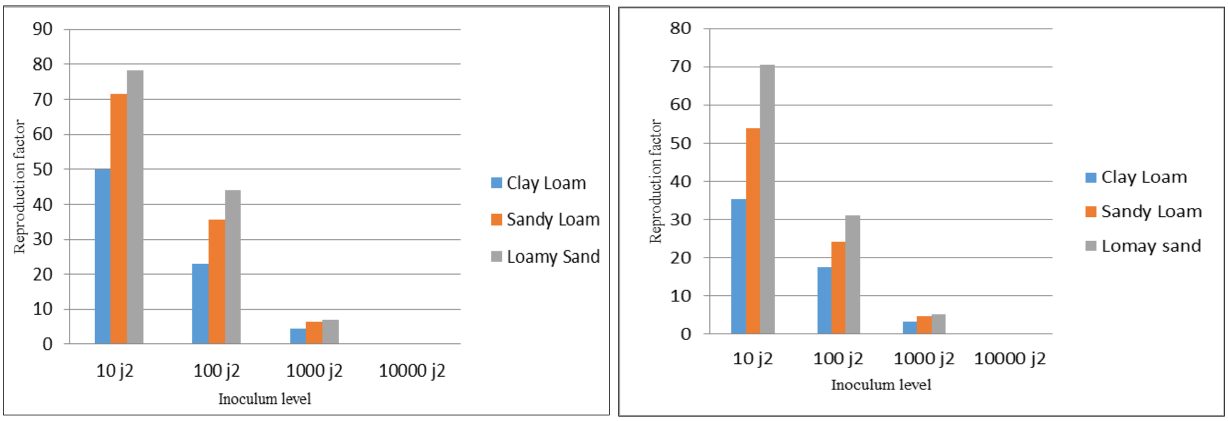
Fig 1: Mean population of *M. graminicola* in scented rice (var. Pusa 1121) in different soil types A) number of eggs per plant B) final nematode population in the soil.



(A) (B)

Fig 2: Mean population of *M. graminicola* in non-scented rice (var. PR 114) in different soil types A) number of eggs per plant B) final nematode population in the soil.

Fig. 3 indicated that reproduction factor of *M. graminicola* was maximum in loamy sand soil followed by sandy loam and clay loam irrespective of inoculum levels. Maximum reproduction factor was found in loamy sand at 10 j_2 and minimum in clay loam at 10000 j_2/kg of soil. Reproduction factor decreased as inoculum levels increased from 10-10000 j_2/kg soil. The highest reproduction was observed at 1000 j_2/kg soil which reduced drastically at 10000 j_2 levels in both the types of rice. The reproduction factor decreased with the increase in Pi, the highest being (78.3) at 10 j_2/kg soil and the least (0.17) at 10,000 j_2/ kg soil in scented rice and on the other hand the highest (70.5) at 10 j_2/kg soil and the least (0.12) at 10,000 j_2/ kg soil in non- scented rice. The decrease in the rate of multiplication at high initial inoculum was due to competition for nutrition among the developing nematodes within a given root system. The same was reported by Chitwood and Feldmesser [2] in *Globodera rostochiensis*, Chitwood [3] in *M. hapla* and Rao & Israel [15] in *M. graminicola*. Probably, the higher population levels of *M. graminicola* in lighter soils (loamy sand) can be explained by a better nematode mobility. Contrary, the oxygen levels and porosity are lower in heavier soils and as a result; the mobility of *M. graminicola* in this soil types is lower.



(A) (B)

Fig 2: Reproduction factor of *M. graminicola* at various inoculum levels in different soil types on scented (A) and non-scented rice (B).

Conclusion

Population densities of *M. graminicola* were inversely related to the percentage of sand, silt and clay. As sand content in the soil increased, nematode reproduction and multiplication was increased correspondingly. In addition to the host plant, soil type is also known to be a major factor that affects nematodes reproduction and its important component for management of plant parasitic nematodes.

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