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Effect of Nematode Inoculum and Soil Texture on Root-knot Development and Yield of Sugarcane

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ABSTRACT

An experiment was conducted to find out the effect of nematode and different soil textures on root-knot disease incidence and yield of sugarcane. In three types of soil texture viz. sandy loam, loamy and silty loam, the sugarcane roots were severely attacked with root-knot disease due to inoculation with *Meloidogyne* spp. Severity of gall and root damage were highest in sandy loam, which was followed by loamy and silty loam textures. The maximum number of 21.0 galls/g root was recorded in sandy loam soil in the month of August. The mean populations of female root-knot nematodes in sandy loam and loamy soil were statistically similar but significantly higher as compared to silty loam texture. Significantly the highest population of 13.2 females/g root was recorded in sandy loam soil in the month of August. Soil textures had significant influence on length per leaf and recovery of sugar. However, highest length of leaf was recorded in silty loam soil. Loamy and silty loam soils gave higher percent of recovery. Non-inoculated canes produced significantly higher number and weight of roots, increased length of roots and higher number of millable canes than inoculated canes under different soil textures. Besides, number of tillers, length of internode and recovery of sugar showed significant negative correlation with the galling incidence and number of female root-knot nematodes.

Key words : *Meloidogyne* spp., nematode inoculum, soil texture, root-knot , yield, sugarcane

INTRODUCTION

The overall population density and composition of nematodes depend primarily on soil factors and can be correlated with gross features of the environment such as soil type and climate (Williams,1969). Spaull (1981) reported that the density of Meloidogyne and Pratylenchus in roots was greatest in sandy soils. Siswojo (1981) reported that nematode populations were higher in light soils than in heavier soils. Nematode numbers in soil increased from the beginning to the middle of the wet season and in roots rapidly increased from the middle to the end of wet seasons. Cadet *et al.* (1982) reported that the effect of soil type on the pathogenicity of nematodes on sugarcane was studied in sandy and clay soils in Upper Volta and Ivory Coast. The presence of nematodes reduced tillering more in light than heavy soil, sett roots being heavily attacked by nematodes in sandy soils; in clay soils nematode attacks were slower. Soil type also altered the nematode population of the roots; in light soil 4 genera were extracted Meloidogyne, Pratylenchus, Hoplolaimus and Paratylenchus and in heavy soil Meloidogyne , Pratylenchus and Scutellonema. Windham and Barker (1986) reported that Meloidogyne incognita reproduced readily on a susceptible soyabean cv in most soil types at 50 locations in North Carolina, USA. There was limited reproduction in muck soils. The relationship between initial population densities and yield varied among soil types and nematode populations. Yield losses were greatest in sandy and muck soils and lower in clay soils. According to Reddy (1987) light sandy soil (coarse-textured) are generally more favourable to large populations of nematodes such as cyst, root-knot, lesion and stubby root nematodes. Hall and Irey (1992) reported that root-knot and stubby-root nematodes were more abundant in sand (95% silica). The effect of different population densities of plant parasitic nematodes on sugarcane was investigated in green house and field experiments by Estioko *et al.* (1988). An initial population of 5100 and 995 nematodes reduced cane

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weight from 36 to 51.20% respectively in sandy loam in the green house, while in clay loam in the field an inoculum of 895 plus a natural population of 1595 decreased cane weight by 26.30%. Species consistently recorded in the green house were *Meloidogyne incognita* , *Pratylenchus* and *Tylenchorhynchus*. In the field *Helicotylenchus*, *Hemicycliophora*, *Hoplolaimus*, *Pratylenchus* and *Rotylenchulus* were most common. Hence to find out the effect of nematode inoculum and soil texture on root-knot development and yield of sugarcane, this experiment was undertaken.

MATERIALS AND METHODS

Soils of the ten selected sugar mill zone areas, namely, Pabna Sugar Mills (PBSM), North Bengal Sugar Mills (NBSM), Joypurhat Sugar Mills (JSM), Rajshahi Sugar Mills (RJSM), Shyampur Sugar Mills (SHSM), Zeal Bangla Sugar Mills (ZBSM), Thakurgaon Sugar Mills (TSM), Setabgonj Sugar Mills (STSM), Carew & Co. and Faridpur Sugar Mills (FSM) are of sandy loam, loamy and silty loam type. The soils of PBSM, NBSM, RJSM, ZBSM, TSM, STSM, Carew & Co are of sandy loam types and those of SHSM and JSM are of loamy and FSM is of silty loam type. Considering these three types of soils, soil from STSM, JSM and FSM were collected for this experiment. The soil was sterilized with formalin (40% formaldehyde) @ 30 ml formalin dissolved in 1000 ml water for per cubic feet of soil. The treated soil was covered with polythene sheets and kept for 72 hours. Then the polythene sheets were removed and the soil was spread in thin layer on the pucca floor for 7 days. Earthen pots were used. Each pot was filled with 12 kg sterilized and dried soil. An earthen plate was placed below each pot to retain excess fluids.

The pot experiment was conducted in a split plot design with five replications. The inoculum of Meloidogyne spp. was tested in whole plots and the three soil textures (viz. sandy loam, loamy and silty loam) were tested in sub-plots. Three sets each of 15 pots (40 cm dia) were used in this experiment. All the three sets of pots were filled with sterilized soil and one month old settling of the sugarcane variety Isd 16 was transplanted in each pot. The pots with settling were watered regularly for normal growth of the cane. When the plants were established, the soil of the pot around the base of the plant was loosened with the help of a 'khurpi' from time to time. Weeding and mulching were done every alternate fortnight upto harvest of the plants. To enhance the growth and root development, the settlings were fertilized into three installments viz. 20 days after plantation, during tillering stage (March/April) and during growth stage(May/June). Each pot received 3.5 g Urea, 2.25 g TSP and 1.5 g MP at the rate of 280, 180 and 120 kg/ha of Urea, TSP and MP, respectively as recommended by Ali *et al.*1989.

After 45 days of transplanting, 15 of these pots (5 for each soil texture) were inoculated with 20 eggmasses collected from tomato roots and brinjal roots previously inoculated with single eggmass of root-knot nematode. These 15 pots were used for recording data on galling incidence and population of root-knot nematodes. Another set of 15 pots (5 for each soil texture) filled with sterilized soil were similarly inoculated with 20 eggmasses and used for recording data on different growth and yield parameters of sugarcane. Another set of 15 pots (5 for each soil texture) were used as control (without eggmass). Data were collected on tiller number, number of galls and eggmasses, population of nematodes, number and length of leaves per plant, number of millable canes, girth of cane, height of cane, length of internode, weight of millable canes, weight and length of root and recovery of sugar.

RESULTS AND DISCUSSION

In the present study, sandy loam soil yielded the highest number of root galls and population of mature females of Meloidogyne spp. as compared to loamy soil and silty loam soil (Table 1 and 2) and (Figure 1, 2 and 3). The findings are similar to the findings of other investigators. Spaull (1981) reported that the density of *Meloidogyne* and *Pratylenchus* in roots was greatest in sandy soils. Siswojo (1981) also observed that nematode populations were higher in light soils than in heavier soils. Reddy (1987) reported that light sandy soil (coarse textured) are generally more favourable to large populations of nematodes such as cyst, root-knot, lesion and stubby-root nematodes.

Table 1 : Number of galls caused by *Meloidogyne* spp. in roots of sugarcane grown in three different soil textures recorded in four different months, 1998-99.

Soil texture	No. of gall/g root in four different months of observation				
	August	September	October	November	Mean
Sandy loam	21.0 a	2.0 bcd	0.4 d	3.4 bcd	6.7
Loamy	3.0 bcd	5.8 b	1.2 cd	5.2 bc	3.8
Silty loam	4.2 bcd	0.0 d	0.0 d	0.0 d	1.1
Mean	9.4	2.6	0.5	2.9	

Values are averages of 5 observations and those in different columns and rows with a common letter(s) do not differ significantly (P=0.05) by DMRT.

Table 2 : Populations of mature females of Meloidogyne spp. in roots of sugarcane grown in three different soil textures recorded in four different months, 1998-99.

Soil texture	Populations of mature females /g root in four different months of observation				
	August	September	October	November	Mean
Sandy loam	13.2 a	2.2 bcd	0.0 d	3.0 bcd	4.2
Loamy	3.4 bcd	5.0 b	0.4 cd	4.0 bc	3.2
Silty loam	4.0 bc	0.0 d	0.0 d	0.0 d	1.0
Mean	6.9	1.8	0.1	2.3	

Values are averages of 5 observations and those in different columns and rows with a common letter(s) do not differ significantly (P=0.05) by DMRT.

In this study, soil textures had significant influence on length per leaf and recovery of sugar. However, highest length of leaf was recorded in silty loam soil (Table 3). Loamy and silty loam soil gave higher percent of recovery (Table 4). These results were supported by Windham and Barker (1986) who reported that yield losses were greatest in sandy and muck soils and lower in clay soils. Similar results were observed in other crops also. Ocimum canum (Ocimum americanum) was grown in clay pots containing either autoclaved loamy sand, sandy loam, sandy clay loam or silty loam soil to determine the effect of these soils in the presence and absence of Meloidogyne incognita on the growth and oil yield under glass house conditions. Oil content in fresh shoot tissue was observed highest in plants grown in silty loam. Overall effect of soil type and/or Meloidogyne incognita inoculation on shoot growth and yield was sigfnificant (Akhtar *et al.*,1998).

Table 3 : Effect of nematode inoculum and soil texture on leaf and root growth of sugarcane during the first crop year 1999-2000.

Treatment	No.of leaves/plant	Length/leaf (cm)	No.of roots/clump	Length of roots/clump (m)	Weight of air dried roots/clump (g)
Soil texture					
Sandy loam	5.5 a	93.56 b	111.90 a	10.85 a	34.10 a
Loamy	4.9 a	99.36 ab	96.50 a	8.33 a	15.70 b
Silty loam	5.6 a	100.40 a	98.40 a	9.10 a	16.60 b
Category of canes					
Inoculated	5.14 a	96.08 a	93.80 b	8.81 a	14.60 b
Non- inoculated	5.54 a	99.52 a	110.70 a	10.04 a	29.67 a

Values are averages of 10 observations in case of soil textures and 15 observations in case of category of canes and those within the same column with a common letter(s) do not differ significantly (P=0.05) by DMRT.

Figure 1. Galling incidence in sugarcane root grown in sandy loam soil

Figure 2. Galling incidence in sugarcane root grown in loamy soil

Figure 3. Galling incidence in sugarcane root grown in silty loam soil

Table 4 : Effect of nematode inoculum and soil texture on tillers, millable canes and recovery of sugar 2000-2001.

Treatment	No.of Tillers/clump	No.of millable canes/clump	Weight of millable canes/clump (kg)	Recovery of sugar (%)
Soil texture				
Sandy loam	6.1 a	2.7 b	1.75 a	8.69 b
Loamy	6.6 a	2.7 b	1.73 a	9.59 a
Silty loam	6.8 a	4.1 a	1.77 a	10.01 a
Category of canes				
Inoculated	6.0 b	3.07 b	1.65 a	9.18 a
Non- inoculated	7.0 a	3.60 a	1.85 a	9.68 a

Values are averages of 10 observations in case of soil textures and 15 observations in case of category of canes and those within the same column with a common letter(s) do not differ significantly (P=0.05) by DMRT.

In the present study it was observed that non-inoculated canes yielded significantly higher number, length and weight of roots and millable canes than those of inoculated canes in sandy loam, loamy and silty loam soils (Table 4 and 5). Besides, number of tillers, length of internode and recovery of sugar showed significant negative correlation with galling incidence and number of female root-knot nematodes (Table 6 and 7). All these phenomena occurred due to the effect of inoculation of eggmasses to the canes. These findings had the conformity with those of Islam et al.(1994) who reported that galling incidence caused the reduction in length of root, weight of root, sugar content, plant height and weight of canes. Jenkins and Taylor (1967) described that symptoms of injury by root nematode resembled those associated with any root injury that interferes with water, nutrient absorption, translocation and physical support of the plant, stunting of growth, an incipient wilting and lowered yield. Agnihotri (1983) reported that the root system of sugarcane affected by nematode displayed a small number of roots and shoot length. In support of the results, Cadet *et al.*(1982) reported that the effect of soil type on the pathogenicity of nematodes on sugarcane in sandy and clay soils in Upper Volta and Ivory Coast. The presence of nematodes reduced tillering more in light than heavy soil, sett roots being heavily attacked by nematodes in sandy soil.

Table 5 : Effect of nematode inoculum and soil texture on leaf and root growth of sugarcane during the second crop year, 2000-2001

Treatments	No.of leaves/plant	Length/leaf (cm)	No.of roots/clump	Length of root/clump (m)	Weight of air dried roots/clump (g)
Soil textur					
Sandy loam	6.81 a	97.48 ab	135.20 a	37.14 a	66.50 a
Loamy	6.66 a	92.72 b	132.60 a	38.48 a	72.30 a
Silty loam	7.40 a	105.28 a	133.10 a	40.05 a	72.30 a
Category of canes					
Inoculated	6.81 a	97.54 a	119.53 b	31.85 b	55.80 b
Non-inoculated	7.10 a	99.39 a	147.73 a	45.26 a	84.93 a

Values are averages of 10 observations in case of soil textures and 15 observations in case of category of cane and those within the same column with a common letter(s) do not differ significantly (P=0.05) by DMRT.

Table 6 : Correlations between galling incidence and yield components of sugarcane under silty loam and loamy soil during the first crop year, 1999-2000 and second crop year, 2000-2001.

Parameters	Silty loam soil		Loamy soil
	1999-2000	2000-2001	2000-2001
	r-value	r-value	r-value
NL × NG	-0.6621	-0.0359	-0.1551
LL × NG	-0.8066	-0.6968	-0.1844
NR × NG	0.0115	0.5661	0.6132
LR × NG	0.2011	0.8264	-0.2415
WR × NG	0.4315	-0.2717	-0.3577
HC × NG	-0.5382	-0.5922	-0.2524
GC × NG	-0.12	-0.3991	-0.3922
LI × NG	-0.9758**	-0.0399	-0.8862*
NT × NG	-0.6621	-0.9131*	-0.1551
NM × NG	-0.5123	-0.2907	-0.1206
WM × NG	-0.4627	-0.6343	-0.0009
RS × NG	-0.7577	-0.6958	-0.9089*

* = Significant at 5% level
** = Significant at 1% level

NL = No. of leaves per plant
LL = Length per leaf
NR = No. of roots per clump
LR = Length of root per clump
WR = Wt. of air dried roots per clump
HC = Height per cane
GC = Girth per cane
LI = Length per internode
NT = No. of tillers per clump
NM = No. of millable canes per clump
WM = Wt. of millable canes per clump
RS = Recovery of sugar
NG = No. of galls per g root.

Table 7 : Correlations between female root-knot nematodes and yield components of sugarcane grown in silty loam soil, 1999-2000.

Parameters	r-value
NL × RN	-0.345
LL × RN	-0.6237
NR × RN	0.2465
LR × RN	0.4329
WR × RN	0.0896
HC × RN	-0.5776
GC × RN	-0.2802
LI × RN	-0.9049*
NT × RN	-0.345
NM × RN	-0.6776
WM × RN	-0.5593
RS × RN	-0.7258

* = Significant at 5% level

NL = No. of leaves per plant
LL = Length per leaf
NR = No. of roots per clump
LR = Length of root per clump
WR = Wt. of air dried roots per clump
HC = Height per cane
GC = Girth per cane
LI = Length per internode
NT = No.of tillers per clump
NM = No. of millable canes per clump
WM = Wt. of millable canes per clump
RS = Recovery of sugar
RN = No. of female root-knot nematode per g root.

In clay soils nematode attacks were slower. It was further reported that soil type also altered the nematode population of the roots. The effect of different population densities of plant parasitic nematodes on sugarcane in different soil texture was investigated in green house and field experiments by Estioko *et al.* (1988). They reported that an initial population of 5100 and 995 nematodes reduced cane weight from 36 to 51.20% respectively in sandy loam in the green house, while in clay loam in the field an inoculum of 895 plus a natural population of 1595 decreased cane weight by 26.30%. Ducusin and Davide (1992) reported that pot trials in the Philippines showed that inoculation of tomato with *Meloidogyne incognita* eggmasses gave 85.3% and 39.9% yield loss if inoculated at planting and at the flowering stage respectively. Besides, it was further observed that the lesion nematode was found pathogenic to maize in red and brown sandy loam and considerably reduced shoot and root weight as reported by Naganathan and Sivakumar (1975).

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