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Pathogenic Potential of Root-Knot Nematode *(Meloidogyne javanica)* on Okra under Different Growing Seasons

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ABSTRACT

Root-knot nematodes (*Meloidogyne* spp.) is a serious pest of okra and its development is usually dependent on temperature and moisture content of the soil. Since, okra is cultivated in different seasons i.e., spring, summer and monsoon under North Indian conditions. So, the experiments on pathogenicity of *Meloidogyne javanica* were carried out under three different growing seasons i.e., spring (March-April), summer (May-June) and monsoon (July-August) for studying the pathogenic potential of *M. javanica* on plant growth parameters as well as on nematode reproduction and multiplication in okra. The current study showed that with the increase of inoculum levels from 10 to 10,000 J_2/kg soil, there was reduction in all plant growth parameters. The inoculum level of 1000 J_2/kg soil was observed to be pathogenic during spring and summer season while, during monsoon season, 100 J_2/kg soil was found to be the pathogenic level to okra crop. An increase in the inoculum level led to significant reduction in growth parameters and also enhanced the nematode reproduction and multiplication under all the three seasons. On the contrary, the reproduction factor was observed negatively correlated with increasing inoculum levels. However at level 10,000 J_2/kg soil, the minimum reproduction factor was observed. It is figured out that the prevailing atmospheric temperature and relative humidity during all growing seasons becomes the crucial factor for the reproduction and multiplication of *M. javanica* because nematode reproduction was maximum during monsoon season crop which had moderate temperature and high relative humidity which in turn increased soil moisture due to rainfall.

Keywords *Abelmoschus esculentus*, Inoculum levels, *Meloidogyne javanica*, Pathogenicity, Reproduction factor.

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INTRODUCTUION

Okra, *Abelmoschus esculentus* (L.) Moench is one of the warm season vegetable crops grown in the tropical and sub-tropical regions of the world. It is generally grown from February to July under North Indian conditions which are divided into three seasons i.e., spring (March-April), summer (May- June) and monsoon season (July- August). This crop is found to be highly susceptible to various biotic and abiotic factors. Among biotic factors, plant-parasitic nematodes (PPNs) are responsible for great losses in vegetable production systems worldwide. An average worldwide crop loss due to PPNs was recorded to

12.6% which is equal to \$215.77 billion annually (Abd-Elgawad and Askary 2015). Root-knot nematodes (RKNs) lead to cause severe damage to various vegetable crops including okra. Yield losses depend on the nematode species, its initial population and cultivated crop variety. Kumar *et al*. (2020) estimated the losses to okra crop caused by *Meloidogyne* spp. to be about 19.5% which was Rs. 2480.86 million in monetary value. It is well known that changes in weather greatly influence biology, virulence, reproduction, sex determination and survival of nematodes (Madulu and Trudgill 1994). Hence, the present study was undertaken to assess the impact of growing seasons on the pathogenic potential of *M. javanica* in okra grown under various seasons.

MATERIALS AND METHODS

The experiments were conducted in the screen house, Department of Nematology, CCS Haryana Agricultural University, Hisar, during the year 2018-19 to study the pathogenicity of *M. javanica* during different growing seasons i.e., spring (March-April), summer (May-June) and monsoon (July-August) in okra crop.

Preparation of nematode inoculum: Pure inoculum of *M. javanica* maintained on eggplant by using single egg mass culture technique, served as the source of nematode inoculum for the present study (Hussey and Baker 1973). Aqueous suspension of second-stage juveniles was thoroughly stirred to homogenize the suspension just before counting and the total numbers of nematodes per ml were counted under stereoscopic microscope and this culture was kept for inoculation.

Raising and maintenance of test plants: The sandy loam soil used for experimentation was steamed sterilized by autoclaving at 121°C at 15 lbs pressure for 20 minutes and filled in 15 cm diameter earthen pots (1 kg soil capacity). Recommended dose of fertilizers was applied to the soil. Seeds of okra cv Hisar Unnat (a susceptible cultivar for root-knot nematode) were sown in these pots and at two leaves stage, one plant per pot was kept and inoculated with nematodes.

Inoculation technique: Ten days old plants were inoculated with freshly hatched second stage juveniles (J_2) of *M. javanica* with different inoculum levels. There were five treatments with four replications including a non-inoculated check arranged in Completely Randomized Design (CRD). The five treatments/ inoculation levels were: 1= non- inoculated check (no nematodes), 2= 10 J_2/ kg soil, 3= 100 J_2/ kg soil, 4= 1000 J_2/ kg soil and 5= 10,000 J_2/ kg soil. The plants were maintained and watered regularly depending upon the atmospheric conditions. Other agronomic practices were followed as per package of practices for okra crop. The observations on plant growth parameters (plant height, fresh and dry shoot and root weight) and nematode reproduction parameters (number of galls per plant, number of egg masses per plant, number of eggs per eggmass, final nematode population in the soil and reproduction factor) were recorded 45 days after nematode inoculation in each growing season.

Weather data: Weekly weather data, for the experimental period, were obtained from the Department of Agricultural Meteorology, CCS HAU, Hisar and presented in Table 4.

Statistical analysis: The data were analyzed by CRD, using statistical software available online at CCS HAU, Hisar (www.hau.ac.in). Treatment means were compared with a critical difference (CD) at 5% level of significance. Nematode parameters were transformed using square root transformation, where required.

RESULTS AND DISCUSSION

Plant growth parameters: Plant height (Fig.1) decreased with increase in the inoculum level of *M. javanica* during all three seasons (spring, summer and monsoon season). Among three seasons, the maximum plant height (46.25 cm) was found in non-inoculated check during monsoon season, while minimum plant height (19.00 cm) was recorded in highest inoculum level (10,000 J_2) during the summer season. The growth was significantly reduced from 1000 J_2 per kg soil inoculum level in spring and summer season while in monsoon season, the reduction was observed from 100 J_2 per kg soil. Maximum fresh shoot weight (18.50 g) was observed in a non-inoc-

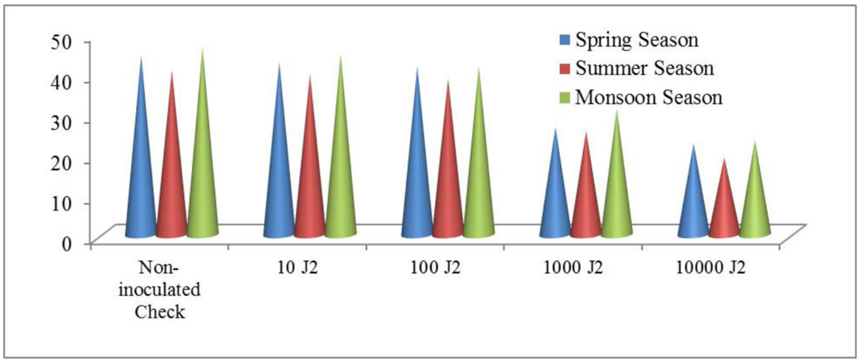

Fig. 1. Comparison of plant height (cm) at different inoculum levels of *Meloidogyne javanica* in okra grown under different growing seasons.

ulated check during the summer season while the minimum was found at highest inoculum level (7.25 g) during the spring season. The results of fresh and dry shoot weight were in a similar trend with that of plant height (Figs. 2, 3). Figs. 4, 5 illustrates the results of fresh and dry root weight which were also in a similar trend as other plant growth parameters for every season.

Nematode multiplication and reproduction parameters: Perusal of data indicated that in all seasons, the minimum number of galls were observed at the lowest inoculum level. The highest number of galls were observed at highest inoculum level during all seasons (Table1; Table 2; Table 3). With an increase in the inoculum level, there was a corresponding increase in the number of galls per plant. Number of galls at each inoculum levels were significantly different from each other at all three seasons. It is clear from data that the number of egg masses per plant were significantly different at each inoculum level (Table1; Table 2; Table 3). It was indicated that in all okra growing seasons, the maximum number of eggmasses were observed at highest inoculum level. The minimum number of eggmasses were observed at the lowest inoculum level during all seasons. As the inoculum level increased, the number of eggmasses increased significantly.

It is depicted from data that the maximum number of eggs/egg mass was recorded at the lowest inoculum level (10 J_2/kg soil) during all seasons while the minimum number of eggs/egg mass was found at highest inoculum level (Table1; Table 2; Table 3). In

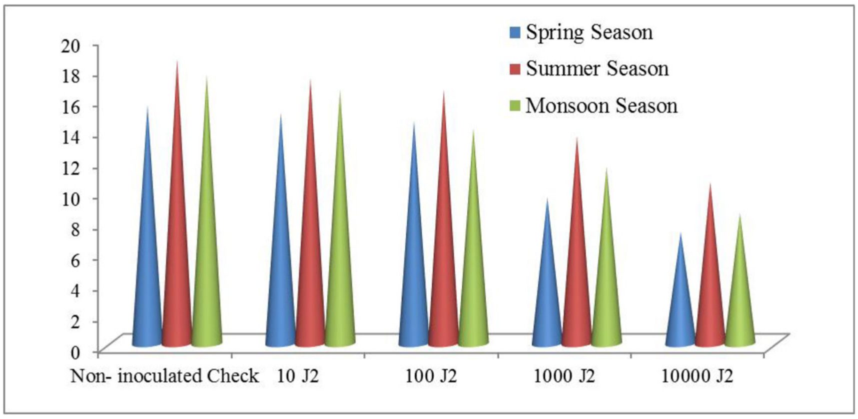

Fig. 2. Comparison of fresh shoot weight (g) at different inoculum levels of *Meloidogyne javanica* in okra grown under different growing seasons.

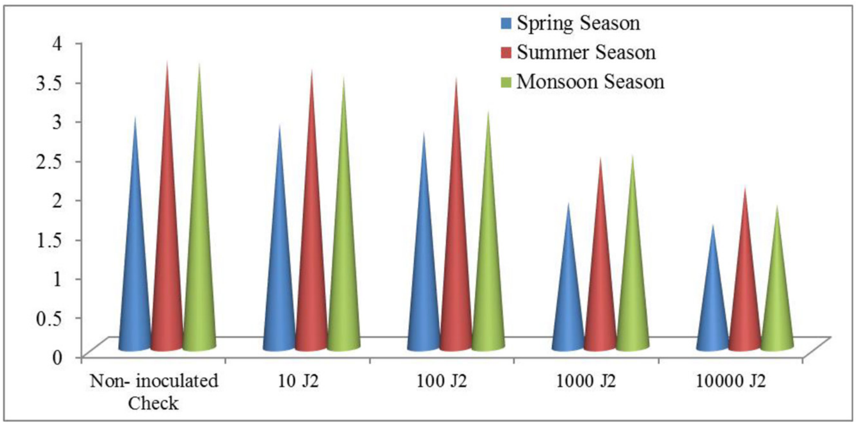

Fig. 3. Comparison of dry shoot weight (g) at different inoculum levels of *Meloidogyne javanica* in okra grown under different growing seasons.

its contrast, the number of eggs/egg mass decreased as the inoculum level increased. The final nematode population was also seen in the increasing trend with increasing inoculum level. The maximum final nematode population was observed at highest inoculum level (10,000 J_2) during all seasons. However, the minimum final nematode population was observed in the 10 J_2/kg soil inoculum level among all the growing seasons. It is depicted in Fig. 6 that reproduction factor (Rf) of *M. javanica* was maximum at 10 J_2/kg soil inoculum level in spring, summer and monsoon season. Contrary to the final nematode population, the multiplication factor decreased as the inoculum level increased. The minimum reproduction factor was found at highest inoculum level in all three seasons.

A negative association between the nematode multiplication and growth parameters of okra suggested that the okra crop was found susceptible to *M. javanica* in the present study. As far as the effect of different inoculum levels is concerned, the significant reduction in plant growth parameters started at 1000 J_2/kg soil in the spring and summer season while in monsoon season the economic damage in terms of plant growth was observed at 100 J_2/kg soil. This shift in threshold level from 1000 to 100 J_2 in

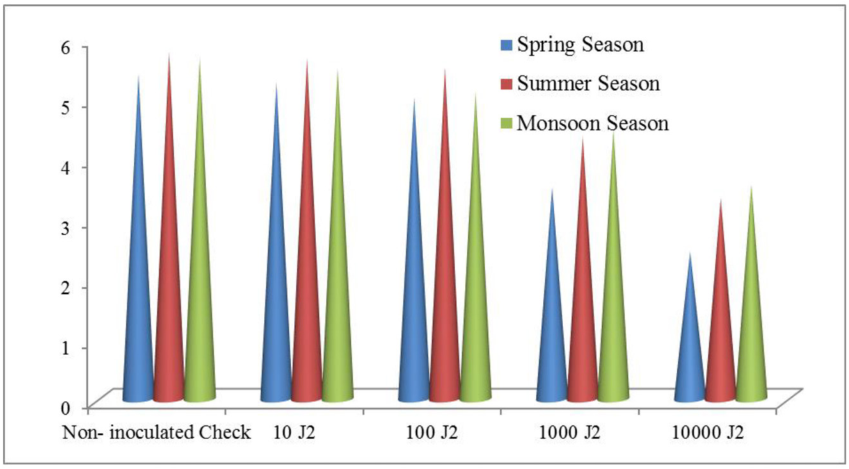

Fig. 4. Comparison of fresh root weight (g) at different inoculum levels of *Meloidogyne javanica* in okra grown under different growing seasons.

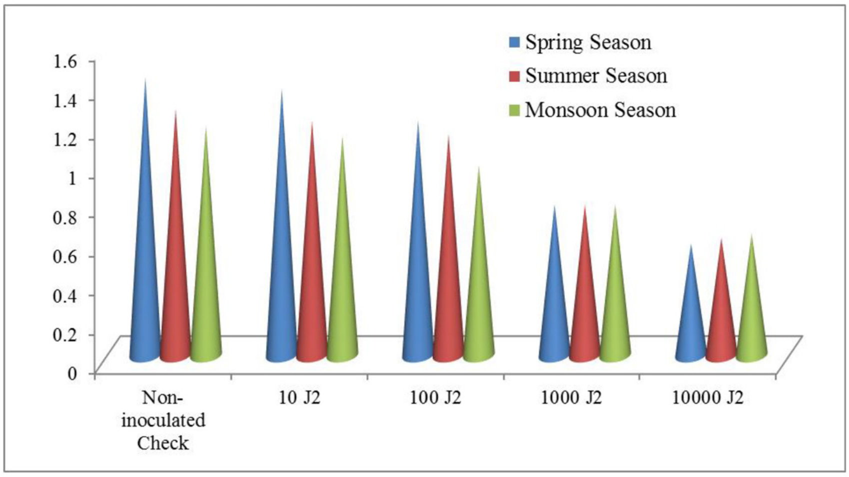

Fig. 5. Comparison of dry root weight (g) at different inoculum levels of *Meloidogyne javanica* in okra grown under different growing seasons.

Table 1. Effect of inoculum levels on reproduction and multiplication of *Meloidogyne javanica* in okra during spring season. Figures in parentheses are √n transformed values.

Inoculum levels (J_2/kg soil)	Number of galls/plant	Number of Eggmasses/ plant	Number of Eggs/eggmass	Final nematode population (J_2/200cc soil)	Reproduction factor (Rf)
10	11.00	6.50	234.50	39.75	157.5
	(3.43)	(2.74)	(15.35)	(6.38)	
100	44.50	30.00	220.50	103.75	67.63
	(6.74)	(5.54)	(14.88)	(10.19)	
1000	99.75	76.00	205.25	357.50	16.06
	(10.04)	(8.77)	(14.36)	(18.90)	
10,000	146.75	103.25	185.25	425.00	1.96
	(12.15)	(10.20)	(13.65)	(20.64)	
CD at 5%	(0.62)	(0.69)	(0.44)	(1.40)	-

the monsoon season was due to abiotic and climatic factors causing this variant response as reported by Kumari *et al*. (2018). The findings of Sawadogo *et al*. (2009) which shows a clear trend of the increasing

Table 2. Effect of inoculum levels on reproduction and multiplication of *Meloidogyne javanica* in okra during summer season. Figures in parentheses are √n transformed values.

Inoculum levels (J_2/kg soil)	Number of galls/plant	Number of eggmasses/ plant	Number of eggs/eggmass	Final nematode population (J_2/200cc soil)	Reproduction factor (Rf)
10	6.75	4.25	174.75	21.00	77
	(2.77)	(2.27)	(13.26)	(4.64)	
100	31.50	14.25	163.00	81.00	24.38
	(5.68)	(3.90)	(12.80)	(9.05)	
1000	75.50	54.50	150.00	303.00	8.55
	(8.75)	(7.45)	(12.29)	(17.36)	
10,000	120.00	76.00	136.50	378.50	1.09
	(10.99)	(8.77)	(11.72)	(19.48)	
CD at 5%	(0.62)	(0.43)	(0.42)	(0.75)	-

Table 3. Effect of inoculum levels on reproduction and multiplication of *Meloidogyne javanica* in okra during monsoon season. Figures in parentheses are √n transformed values.

Inoculum levels (J_2/kg soil)	Number of galls/plant	Number of eggmasses/ plant	Number of eggs/eggmass	Final nematode population (J_2/200cc soil)	Reproduction factor (Rf)
10	14.00	9.25	296.50	38.00	279.46
	(3.86)	(3.30)	(17.25)	(6.22)	
100	55.25	49.25	285.75	150.00	142.78
	(7.47)	(7.08)	(16.93)	(12.24)	
1000	171.25	90.00	275.75	389.25	25.38
	(13.12)	(9.54)	(16.64)	(19.69)	
10,000	202.75	139.00	265.50	486.00	486.00
	(14.27)	(11.83)	(16.32)	(22.07)	
CD at 5%	(0.71)	(0.58)	(0.26)	(1.83)	-

Table 4. Different weather parameters prevailed during spring, summer and monsoon season.

Weather parameters	Maximum temperature (°C)	Minimum temperature (°C)	Maximum relative humidity (%)	Minimum relative humidity (%)	Rainfall (mm)
Spring season	34.8	17.0	67	33	14.00
Summer season	40.8	26.4	65	40	17.10
Monsoon season	34.7	26.6	90	69	128.70

prevalence of *Meloidogyne* sp. with increases in the rainfall, soil moisture and humidity profiles of the agro-climatic zones during a survey. In the spring and summer season, maximum plant growth was recorded in a non-inoculated check and low inoculum levels (10, 100 J_2/kg soil). As *M. javanica* caused a significant reduction in plant growth parameters, the reduction was directly proportional to the increasing inoculum levels in this study and is confirmed by Paruthi and Gupta (1985). The maximum reduction in plant growth was found at the highest inoculum level (10,000 J_2). In the present investigation, the damaging

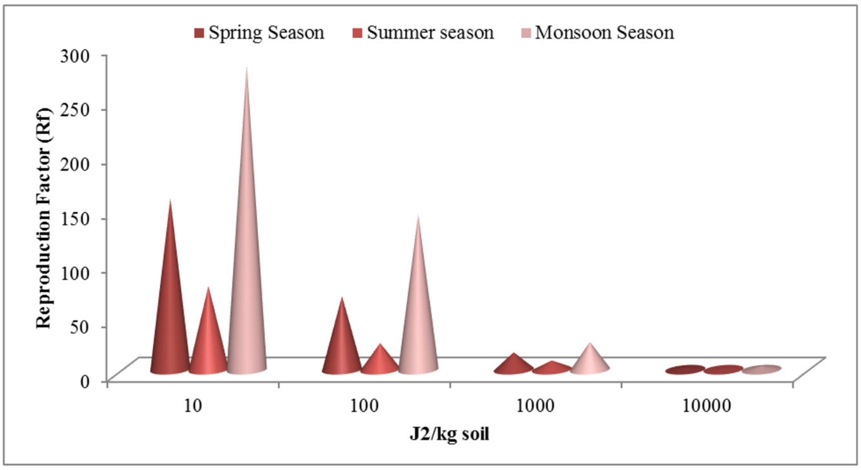

Fig. 6. Reproduction factor (RF) of *Meloidogyne javanica* at different inoculum levels in okra during spring, summer and monsoon season.

threshold level was 1000 J_2/kg soil during the spring and summer season of okra cultivation. These results confirm with findings of Mahalik and Sahoo (2016) who observed 1000 J_2 of root-knot nematode to be pathogenic level in okra crop at temperature range 21°- 35°C. The reduced growth of okra plants was due to *M. javanica* which has high reproduction potential with short life cycle resulted in multiple generations in a crop season, thus, caused severe losses even at low inoculum level (Moens *et al.* 2009). In the present study, the variation in pathogenic levels of root-knot nematode during all the growing seasons was only due to the occurrence of varied environmental conditions. There is a clear depiction of data on nematode reproduction and multiplication which was comparatively more in monsoon season compared to spring and summer season. As per Table 4, Low temperature during spring season inhibited and prolonged the nematode development while higher temperature reduced the survival rate as well as the fecundity of the nematode in the summer season (Tsai 2008).

With an increase in the inoculum level, there was an increase in all nematode reproduction parameters. This study reported that the minimum number of eggs/eggmass were found at the highest inoculum level. Rizvi (2011) revealed that there was an increase in eggs/eggmass with an increase in the inoculum level. In the present study, the intensity of gall formation increased with the increase in the number of nematodes inoculated. The reproduction factor of *M. javanica* was maximum at the lowest inoculum level and vice versa. The nematode reproduction rate was inversely proportional to the increasing inoculum level. It might be due to the competition among nematodes on the host for infection, food and space at a higher level. At low inoculum level sufficience space at root is available to the nematodes for penetration development and multiplication. Thus leading to higher reproduction factor. Lesser are the nematodes, lesser is the competition and therefore, greater is the reproduction factor (Das 2013). Hussain *et al.* (2011) observed that this might be due to the destruction of the root system by the parasitism of root-knot nematode which makes less available avenues for penetration of the developing nematodes and also due to inability of juveniles to find out newer infection sites for subsequent generations.

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