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Life Cycle and Pathogenicity of *Meloidogyne incognita* on *Capsicum frutescens* under Poly-House as Compared to Screen-House Conditions

Priyanka Duggal, Sewak Ram, A. K. Bhatia[*] and Jaydeep Patil

Department of Nematology and *Department of Vegetable Science

CCS HAU Hisar, Haryana 125004, India

*Corresponding Author E-mail: duggalpriyanka65@gmail.com

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ABSTRACT

The life cycle and pathogenicity of root-knot nematode (Meloidogyne incognita) studied on Capsicum under polyhouse as well as screen house conditions for comparision. Nematode development was observed faster under polyhouse condition (35 days) as compared to screen-house (40 days). The pathogenicity of root-knot nematode at the different inoculum levels viz., 0, 10, 100, 1,000 and 10,000 J_2 of Meloidogyne incognita /pot resulted into significant reduction in plant growth parameters at pathogenic level of nematode at and above 1,000 J_2 inoculum level under both the conditions but plant growth parameters like shoot length (37.7 cm), fresh shoot weight (10 g), dry shoot weight(3 g), fresh root weight(9.3 g), dry root weight (2.9 g) and nematode reproduction parameters viz. number of galls per root system, no. of egg masses per root system and final nematodes population was recorded higher under polyhouse conditions due to optimum condition for both, plant and nematode.

Key words: *Polyhouse, screen house, root-knot nematode, Capsicum, life cycle, pathogenicity and growth parameters.*

INTRODUCTION

Capsicum (*Capsicum frutescens*) is variously called as green pepper, sweet pepper, bell pepper, etc. It belongs to the family Solanaceae. This crop is successfully grown under the protected cultivation which is an emerging technology for raising high value crops in tropical and sub-tropical climatic conditions of the country and it has very good potential especially in semi-urban areas around cities. The protected cultivation has shown high productivity, better quality produce, early maturity and year round cultivation of plants due to controlled environmental conditions hence gives manifolds increase in yield per unit area. Though in the polyhouses, crops are grown under protected conditions, yet the crops are not protected as it involves intensive cultivation of crops, optimum use of fertilizers and frequent use of irrigation, but continuous growing of the same crop with high day temperature and relative humidity within the greenhouse, polyhouse and low tunnel along with poor plant hygienic conditions inside and outside the greenhouse increase problem of soil borne pests and diseases including plant parasitic nematodes which results in the availability of ideal conditions for the growth and multiplication of these pests.

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Among the plant parasitic nematodes, root-knot nematode (*Meloidogyne* spp.), is the most destructive and difficult to control in protected cultivation system. The crops which are grown throughout the year under polyhouse conditions are seriously affected with root-knot nematodes (*Meloidogyne* spp.) which cause severe damage to crops and ultimately increase the economic losses. In Haryana, in a field naturally infested with *M. incognita* at 28-34 J_2/g soil, losses in yields of okra, tomato and brinjal were 90.9%, 46.2%, and 27.3%, respectively[4]. Reddy[16] observed 39.8% reduction in tomato yield in a field infested with nematode population at 20 J_2/g soil.

MATERIAL AND METHODS

Present study was carried out to determine the life cycle and pathogenicity of root- knot nematode, *M. incognita* in Capsicum crop under polyhouse of the Department of Vegetable Science and screen house of the Department of Nematology, CCS Haryana Agricultural University, Hisar. Pure inoculum of root-knot nematode (*Meloidogyne incognita*) was prepared by single egg masse culture. For life cycle experiment, 1,000 J_2 per pot (6" diameter) were inoculated. The pots were filled with steam sterilized sandy loam soil autoclaved at 121±1^{0}C temperature and 15 lbs pressure. Each pot was transplanted with seedling of Capsicum crop. The seedlings were inoculated with 1,000 freshly hatched second stage juveniles of *M. incognita* per pot on to the exposed roots. Each treatment was replicated three times with completely randomized design.

The experiment on Pathogenicity of root-knot nematode, *M. incognita* was conducted using the planting material brought from a Govt. nursery. The pots were filled with steam sterilized sandy loam soil. The seedling planted in these pots after mixing well decomposed farm yard manure. The seedlings were inoculated with freshly hatched second stage juvenile of *M. incognita* with different inoculum levels viz., 0, 10, 100, 1,000 and 10,000 J_2 per pot on to the exposed roots. Each treatment was replicated three times with completely randomized design.

The seedlings were uprooted after 45 days of inoculation and observations on plant growth parameters *viz.* Shoot length, Fresh shoot weight, Fresh root weight, Dry shoot weight, Dry root weight and nematode multiplication parameters *viz.* no. of galls and eggmasses per root system, final nematode population was recorded**.**

RESULTS AND DISCUSSION

Life cycle of root-knot nematode in Capsicum under screen house and polyhouse conditions:

The observations presented in Fig. 1 revealed that under screen house conditions, J_2 penetration started at root tips on 2nd day and maximum penetration was observed on 6th day. J_2 started swelling on 11th day (J_2 with spike tail) which became J_3 on 14th day and continued up to 20th day. On 23rd day, J_4 stage was detected which started further swelling and after 6 days, female was observed on 29th day. Gravid female was observed on 35th day. Gravid female with eggmasses and J_2 in soil were observed on 40-45th days. Under polyhouse conditions, J_2 penetration started at root tips on 2nd day and maximum penetration was observed on 4th day, J_2 started swelling on 8th day (J_2 with spike tail) which became J_3 on 11th day. There was no further development of J_3 up to 17th day. On 20th day, J_4 stage was detected which started further swelling. After 6 days i.e. on 26th day, female was observed while gravid female was observed on 29th day. Gravid female with eggmasses and J_2 in soil were observed on35th day. Same observations were recorded up to 45th days.

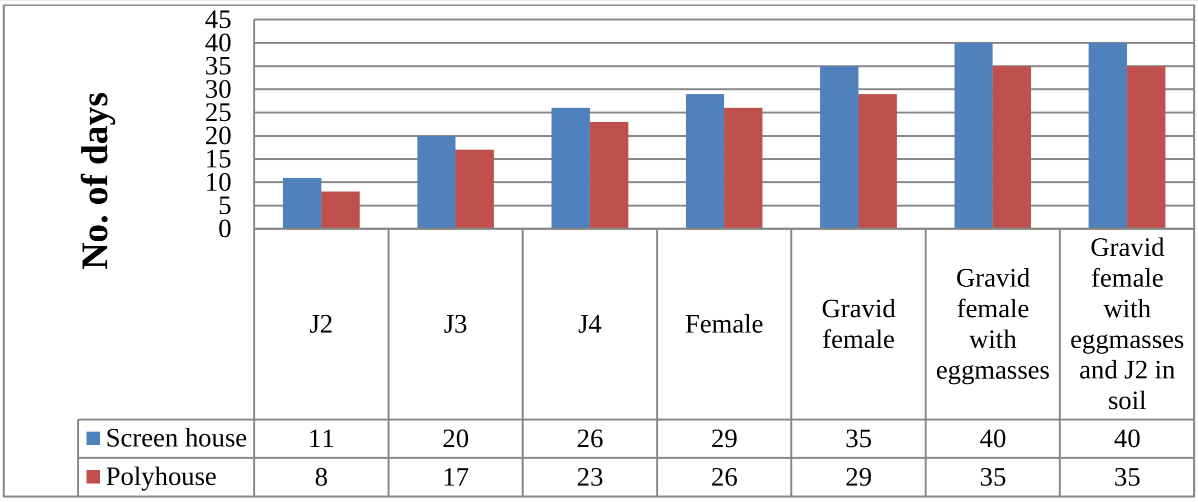

Fig. 1: Comparison between life cycle of root-knot nematode under screen house and polyhouse conditions in Capsicum

Capsicum crop was transplanted on 12 Oct 2014, the result showed that root-knot nematode completed its life cycle in 40 days under screen house condition (Temp. 7.7-33.7 ^{0}C) and in 35 days under polyhouse condition (Temp. 12.7-38.7 ^{0}C). The results for both given conditions are in agreement with those of Al-Sayed *et al.*[1], who studied the life cycle of *M. incognita* on tomato, okra, pepper, cowpea, sunflower and soybean. They observed that life cycle of *M. incognita* varied according to temperature and host type. In tomato, okra, pepper and cowpea *M. incognita* required 28 days at 32±5 ^{0}C to develop and produce second stage juveniles of the next generation, 21 days were sufficient in sunflower but 35 days were required in soybean. At lower temperature of 20±5 ^{0}C the nematode needed 35 days to produce the next generation in tomato, sunflower, okra and soybean, 42 days in cowpea and 49 days in pepper. Anamika & Simon[2] recorded the life cycle of *M. incognita* in tomato and brinjal seedlings during different months at different temperature. The life cycle of *M. incognita* seems to be related with temperature. They reported that during the month of November the life cycle was completed in 25 days. The results are in collaboration with as that of Curto *et al.*[6], studied a susceptible tomato cultivar (UC82) in pots to collect more complete observations of the nematode life cycle on the selected plant roots. Plants were cultivated in the glasshouse for 14–15 weeks and evaluated every 2 weeks. Root gall rating, population reproduction factor and life cycle duration showed wide differences amongst the different accessions and the life cycle of *M. incognita* was not completed, even after 15 weeks.in *Rapistrum rugosum* sel. ISCI 15. Mahapatra & Swain[13] reported that life cycle (J_2 to J_2) of *M. incognita* on black gram was completed within 32 days at a temperature range of 18-34 ^{0}C. The juveniles started penetrating roots as early as 12 hrs after inoculation and continued up to 6th day. Initiation of moulting in J_2 was observed on 8th day of inoculation and completed on 14th day. Third moulting started on the 16th day and was completed on 22nd day of inoculation and young females developed. Mature females secreted egg sacs on 26th day of inoculation. Singh & Kumar (1998) studied the life cycle of *M. incognita* on Japanese mint (*Mentha arvensis*). Life cycle of *M. incognita* on Japanese mint (*Mentha arvensis* cv. 'Shivalik') was completed from J_2 to J_2 in 29 days at temperature 13 ^{0}C-37 ^{0}C during March and April. Tarjan[18] reported that the egg production of females started 39 days after inoculation for *M. incognita*, on *Antirrhinum majus*.

Pathogenicity of root-knot nematode in Capsicum under screen house and polyhouse conditions

The data recorded on various plant growth parameters and nematode parameters of root-knot nematode revealed that all the growth parameters decreased with increase in inoculum levels of root-knot nematode, *Meloidogyne incognita* under screen house (Table 1) and polyhouse conditions (Table 2).

Under Screen house conditions: The maximum shoot length (33.3 cm) was observed in uninoculated control which differed significantly at 1,000 J_2 level (25.7 cm), being minimum (22.2 cm) at 10,000 J_2 level. Fresh shoot weight (9.4 g) was recorded in uninoculated control. Minimum shoot weight (4.7 g) was recorded at 10,000 J_2 level. Significant reduction in dry shoot weight was observed at and above 1,000 J_2 level (1.3 g), being minimum at 10,000 J_2 level (0.6 g) as compared to uninoculated control level where mximum dry shoot weight (2.3 g) was observed. Fresh root weight was found maximum (11.3 g) in uninoculated control which differed significantly at and above 1,000 J_2 /plant (5.1 g), being minimum (3.8 g) at highest inoculum level of 10,000 J_2/plant. Maximum dry root weight (2.6 g) was recorded in uninoculated control. However, the differences at 1,000 (1.4 g) and 10,000 J_2 inoculum level (1.0 g) were statistically non-significant.

Minimum no. of galls (4.0/plant) was observed at inoculum level of 10 J_2/plant, being maximum (242.3/plant) at highest inoculum level of 10,000 J_2/plant followed by 183.7 galls at 1,000 J_2/plant. Maximum number of eggmasses (118.7) was observed at 10,000 J_2 inoculum level followed by 1,000 J_2 level (90.7) and 17.3 at inoculum level of 100 J_2/plant. However, no eggmasses were found at 10 J_2 inoculum level.

Final nematode population was found maximum (15036.3 J_2/kg soil) at inoculum level of 10,000 J_2 followed by 1361.3 J_2/kg soil at inoculum level of 1,000 J_2/plant. Minimum number of larvae (12.7/kg soil) was recorded at inoculum level of 10 J_2/plant followed by 100 J_2 at inoculum level (146.3 J_2/kg soil).

Number of galls, eggmasses and final nematode population increased with increase in inoculum level conspicuously at and above 1,000 J_2 level

Under polyhouse conditions: Data in Table 2 showed that maximum shoot length (37.7 cm) was recorded in uninoculated control, however, significant differences in shoot length were observed at and above 1,000 J_2 inoculum level (31.3 cm) which differed significantly from 10,000 J_2 inoculum level (27.7 cm). Fresh shoot weight was found maximum (10.0 g) at 0 inoculum level and significant differences in shoot weight were observed at and above 100 J_2 level (8.2 g), being minimum (5.0 g) at 10,000 J_2 inoculum level. Significant differences in dry shoot weight in control (3.0 g/plant) were observed at and above inoculum level of 1,000 J_2/plant (1.1 g), being minimum (1.0 g) at inoculum level of 10,000 J_2/plant. The differences in dry shoot weight at 1,000 (1.1) and 10,000 J_2 (1.0) inoculum level were statistically non-significant. Fresh root weight was found maximum in (9.3 g) in uninoculated check, being minimum in (3.8 g) at highest inoculum level 10,000 J_2/plant and 5.7 g at 1,000 J_2 level. Significant reduction in dry root weight over uninoculated check (2.9 g) was observed at and above 1,000 J_2 level (1.6 g), being minimum in (1.2 g) at an inoculum level of 10,000 J_2/plant. Number of galls per root system was found maximum (151.6) at highest inoculum level of 10,000 J_2/plant followed by 1,000 J_2 level (108.3). The significant differences in number of galls at 1,000 J_2 level (108.3) and 10,000 inoculum level (151.6) were recorded. Maximum number of eggmasses (107.7) were recorded at highest inoculum level of 10,000 J_2/plant followed by 1,000 J_2/plant (66.0) which differed statistically with each other, however, only 11.0 eggmasses/root system were observed at 100 J_2 level of inoculation which were significantly less than that at 1,000 and 10,000 J_2 inoculum level. Final nematode population also increased with increase in inoculum level. Maximum final nematode population (18335.7 J_2/kg soil) was recorded at inoculum level of 10,000 J_2 level followed by 1603.3 J_2/kg soil at inoculum level of 1,000 J_2 which were statistically different from each other. Final nematode population at 100 J_2

level (156.7) was significantly less than that at 1,000 and 10,000 J_2 level. The Fig. 2 indicates that maximum shoot length, fresh shoot weight, dry shoot weight, fresh root weight and dry root weight was observed under polyhouse conditions.

On the basis of the information, obtained from the data in Table 1 & 2 regarding pathogenic level of *Meloidogyne incognita* in Capsicum under screen house and polyhouse conditions, it is revealed that inoculum level of 1,000 J_2/plant was pathogenic under both the conditions, however, all the growth parameters except fresh root weight were comparatively more in case of polyhouse conditions as compared to screen house conditions but nematode reproduction parameters except final nematode population was recorded maximum under screen house condition (Fig. 2 & 3).

Table 1: Effect of root-knot nematode, *Meloidogyne incognita* on plant growth parameters and nematodes reproduction factor in capsicum under screen house conditions (Mean of three replicates)

Inoculum levels	Shoot length (cm)	Fresh shoot weight (g)	Dry shoot weight (g)	Fresh root weight (g)	Dry root weight (g)	No. of galls per root system	No. of eggmasses per root system	FNP (J_2 in soil)
0	33.3	9.4	2.3	11.3	2.6	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)
10	32.7	8.3	2.0	10.0	2.3	4.0 (2.3)	0.0 (1.00)	12.7 (3.7)
100	30.9	7.8	1.8	8.7	2.0	48.6 (7.0)	17.3 (4.2)	146.3 (12.3)
1,000	25.7	6.4	1.3	5.1	1.4	183.7 (13.6)	90.7 (9.6)	1361.3 (37.0)
10,000	22.2	4.7	0.6	3.8	1.0	242.3 (15.6)	118.7 (10.9)	15036.3 (122.5)
C.D. (P= 0.05)	3.0	1.2	0.16	1.8	0.3	(0.1)	(0.2)	(3.2)

- Figures in parentheses are √n+1 transformed value

Table 2: Effect of root-knot nematode, *Meloidogyne incognita* on plant growth parameters and nematodes reproduction factor in capsicum under polyhouse condition (Mean of three replicates)

Inoculum levels	Shoot length (cm)	Fresh shoot weight (g)	Dry shoot weight (g)	Fresh root weight (g)	Dry root weight (g)	No. of galls per root system	No. of eggmasses per root system	FNP (J_2 in soil)
0	37.7	10.0	3.0	9.3	2.9	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)
10	36.0	9.1	2.5	8.4	2.6	20.0 (4.6)	0.0 (1.0)	13.3 (3.8)
100	35.3	8.2	2.3	8.0	2.4	33.3 (5.8)	11.0 (3.5)	156.7 (12.5)
1,000	31.3	6.7	1.1	5.7	1.6	108.3 (10.4)	66.0 (8.2)	1603.3 (40.0)
10,000	27.7	5.0	1.0	3.8	1.2	151.6 (12.3)	107.7 (10.4)	18335.7 (135.4)
C.D. (P= 0.05)	3.4	0.6	0.6	2.0	0.5	(0.4)	(0.2)	(0.4)

- Figures in parentheses are √n+1 transformed value

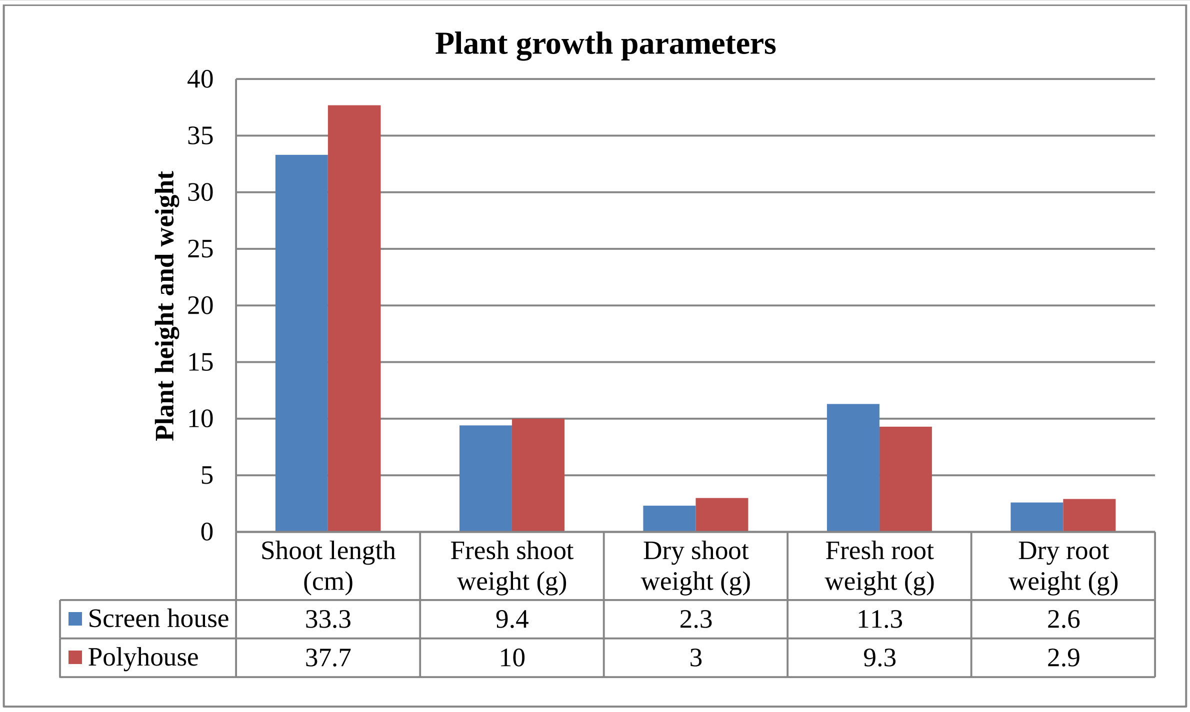

Fig. 2: Comparison between growth parameters of capsicum under screen house and polyhouse conditions

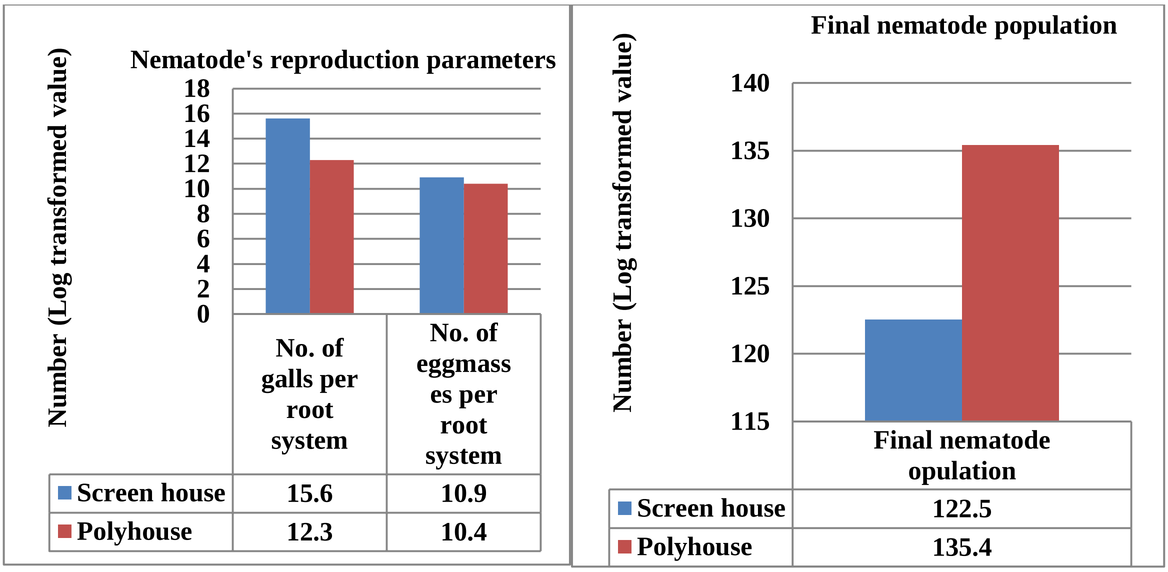

Fig. 3: Comparison between root-knot nematode reproduction parameters under screen house and polyhouse conditions in capsicum

The pathogenic level of root-knot nematode in Capsicum was recorded at and above 1,000 J_2 inoculum level under both the conditions but most of the plant growth parameters and nematode reproduction parameters were recorded higher under protected cultivation, perhaps due to optimum condition for plant and nematode, both. The results of pathogenicity of root-knot nematode at the prescribed inoculum levels are in agreement with that of Pankaj & Siyanand[15] who studied the effect of initial inoculum levels on gerbera, capsicum and strawberry viz., 0, 10, 100, 1,000 and 10, 000 J_2 of *M. incognita* /kg soil on bitter gourd and round melon under pot conditions and reported that significant reduction in plant growth was observed at all the initial inoculum levels. The damaging threshold level in bitter gourd was found to be 1 J_2/g soil as against 10 J_2/g soil in round melon. Ansari *et al*.[3], who conducted an experiments under net house condition to determine the individual effect of different inoculum levels of root-knot nematode, *Meloidogyne incognita*, Race-2 on plant growth parameters viz., Plant length, fresh and dry weights and number of fruits of tomato var. P21. The threshold level of root-knot nematode was 1000 J_2/kg soil. Inoculum level of *Meloidogyne incognita* race-2 was pathogenic at and above 1000 J_2/kg soil and caused significant reduction. Choi *et al*.[5], who studied the effects of *Pratylenchus coffeae* on growth of *Gerbera jamesonii* cv. Teracombi in a greenhouse. At inoculum levels of 1,000, 5,000 and 10,000 nematodes, fresh shoot and root weights were reduced by 69, 76 and 85 per cent. Six months after planting, plants inoculated with 1,000 and 5000 nematodes, the number of flowers decreased by 81 per cent and 95 per cent respectively, while 10,000 nematodes per plant produced no flowers. Dhankar *et al*.[7], who reported that the threshold inoculum levels of *M. incognita* on water melon (*Citrullus vulgaris* Scharad) was 1,000 larvae/kg soil. At this inoculum levels all the plant growth parameters were significantly reduced over control. Ganaie *et al*.[8], who observed a significant reduction in various plant growth parameters of okra at and above the inoculum level of 1,000 J_2 / 2 kg soil of *M. incognita*. Gupta *et al*.[9], who reported the effect of various initial inoculum levels viz., 0, 10, 100, 1,000, 2,000, 5000 and 10, 000 J_2 of *Meloidogyne spp*. /kg soil on some cucurbitaceous crops. They found significant reduction in growth of all the crops at initial inoculum level of 1,000 J_2/pot. Galling was found maximum at highest initial population density. Hazarika & Phukhan[10] also reported that the significant reduction in height, root and shoot weight of plants was at an inoculum level of 1,000 nematodes/plant.

Johnson *et al*.[11], reported the damage potential and pathogenic levels of *M. incognita* on gladiolus and carnation under glasshouse conditions. Growth parameters like shoot and root length, shoot and root weight and number of leaves were significantly reduced by different inoculum levels (10, 100 and 10,000 J_2/plant) of *M. incognita* in both gladiolus and carnation. The reproduction rate of *M. incognita* on these crops was drastically reduced at higher inoculum levels (10,000 J_2/plant). It was also observed that even 100 J_2/plant were able to cause economic damage to gladiolus and carnation. Khanna & Jyoti[12] reported the pathogenic potential of *M. incognita* on *Dianthus caryophillus*. Plant growth was significantly reduced at the levels of 1,000 and 10,000 juveniles as compared to control. Meena & Mishra[14] observed *M. incognita* causes a significant reduction in almost all the plant growth parameters with increase in the levels of nematode inoculum. Maximum reduction in all the plant growth parameters was recorded at the inoculum level of 10,000 J_2/pot which was followed by the levels of 1,000 J_2/pot.

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