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Assessment of summer vegetable resistance to *Meloidogyne incognita* and the possibility of the inoculum

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Seven vegetable genotypes, including tomato (*Lycopersicon esculentum* L), eggplant (*Solanum melongena* linn), cucumber (*Cucumis sativus* L), and okra (*Hibiscus esculentus* L), planted at significant vegetable production areas, were the subject of a systemic survey to determine the association of plant parasitic nematodes and to evaluate the losses. Twenty locations around the vegetable growing region were used to gather 130 samples. The findings indicated that plant parasitic nematodes were present in 85% of the vegetable fields. In decreasing frequency, the plant parasitic nematodes discovered infecting vegetables were *Helicotylenchus* spp. (Steiner) (3.2%), *Xiphinema* spp. (Cobb) (5.1%), *Meloidogyne javanica* (Treub) (6.0%), *Pratylenchus* spp. (Thorne) (15.2%), and *M. incognita* (Kofoid & White) Chit. (85.0%) The average prevalence of plant parasitic nematodes was 47.19%, ranging from 0 to 85.0%. In the majority of the examined vegetable crops, *Pratylenchus* spp. and *M. incognita* population concentrations were possibly hazardous. We found yield losses of 32.5% for four commercially cultivated vegetables, greater than those in industrialized nations. Increased losses might result from growers' ignorance of these plant parasitic nematodes. Experiments were conducted in the greenhouse at a temperature of 25°C to test seven summer vegetables for Meloidogyne incognita infection. Cucumber roots had much more galls and egg masses at harvest than the other genotypes' roots. *M. incognita*'s invasion and growth were tested on cucumbers. The way each therapy responded to the M. incognita infection varied. Maximum nematode invasion and growth were seen across all treatments. Relationship between root weight and the quantity of *M. incognita* growing.
Keywords: Cucumber**,** Nematode, association, vegetable, Tomato, okra, eggplant.

INTRODUCTION

Pakistan's real economy is built on agriculture. More than 75% of the people in the nation's rural areas depend entirely or partly on this discipline. The main summer vegetables cultivated in the nation include tomato, pumpkin, okra, spong gourd, cucumber, bittergaurd, and eggplant. Several agroclimatic factors in Pakistan have made cultivating a huge selection of vegetable crops feasible. It offers the chance for year-round availability of several vegetable crops in various parts of the nation. The different vegetables are cultivated in Pakistan over around 225-239 thousand hectares. Pumpkin, Okra, bitter guard, brinjal, sponge guard, and cucumber are just a few of the numerous vegetables grown in Pakistan. High nutritional value and protein content, they are in high demand commercially. Vegetables are essential for human nutrition, particularly as sources of the vitamins C, A, B6, Thiamine, Niacin, and E, minerals, and dietary fibre (Quebedeaux and Bliss, 1988; Wargovich, 2000; Quebedeaux and Eisa, 1990). Due to changing dietary habits and increased health awareness, vegetables are now a staple of daily meals in the ordinary family. In addition, the increasing pace of population expansion has increased the need for fundamental dietary veggies. As a result, the country and its cities have a year-round high need for vegetables. This is brought on by heightened health consciousness, rapid population expansion, altered eating habits of an expanding middle class of wealthier people, and the accessibility of packaged veggies.

Vegetables in the diet shield the body from chronic conditions like cancer (Willett, 1994; Heber, 2004). This is mostly

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related to the antioxidant and anti-proliferative properties of different phytochemicals found in abundant concentrations in fruits and vegetables (Proteggente *et al.,* 2002; Chu *et al.,* 2002; Sun *et al.,* 2002). Water-soluble vitamin C (L-ascorbic acid) is present in varying amounts in various plants (Iqbal *et al.,* 2004). Cucumber and bitter gourd were among the veggies with the highest ascorbic acid content. Our nation's environment favors nematode activity and reproduction throughout the year. Sandy, warm soil like that found in the desert zone is ideal for the growth and infection of nematodes. Perennial crops and crops produced continuously in irrigated locations are frequently severely damaged by worms.

This study aimed to determine how various summer vegetables responded to Meloidogyne incognita and how different Meloidogyne incognita inoculum concentrations affected the development of summer vegetable plants and nematode reproduction.

MATERIALS AND METHODS

***Root and Soil Sample Collection*:** Summer crop (cucumber, eggplant, sponge gourd, bitter gourd, tomato, okra, and pumpkin) root-knot nematode (RKN) infection levels need to be assessed at grower's fields situated at the key vegetable-producing region of District Bahawalpur, a systematic study was carried out. Around the plant rhizosphere, 18 cm deep soil samples were taken using a trowel, and composite samples were created. A trowel was used to gently remove root samples from the rhizosphere of vegetable plants that had around 1 kg of dirt adherent to them. Samples were placed in polythene bags with information on the host, location, soil type, etc. To keep the samples fresh, they were immediately transported to the lab and put in a refrigerator.

***Soil sample*:** After three cores, the soil samples were well mixed, and 100 cm3 composite samples were added to a plastic bucket along with one to two litres of tap water. The water and soil samples were completely mixed until all clods were broken up. Samples were processed through the 100, 250, and 350 mesh sieves. The first phase, the water was run through a sieve with a mesh size of 100. After whirling the water suspension and allowing it to settle, the water supernatant from the second bucket was gently filtered through a fine sieve (250 mesh sieves) and then allowed to drain. The remaining substance was then transferred into a beaker from the 325-mesh sieve. After being allowed to settle to the bottom of the beaker for one to five minutes, the suspension was poured through the funnel that had been lined with tissue paper.Three days were given to the nematodes to extract. Samples were collected after three days and counted using a stereo-binocular microscope.

***Root samples*:** Roots were washed, blotted on paper, damp-dried, and weighed to remove the dirt. According to Quesenberry et al. (1989), the root system's galling index was graded on a scale of 0 to 5.

Scale	Number of galls /eggmasses
0	0
1	1-2
2	3-10
3	11-30
4	31-100
5	>100

The following formula assessed the incidence of infestation of root knot nematode.

$$\text{Incidence} = \frac{\text{nematode infested samples}}{\text{Total samples}} \times 100$$

The entire root system was diced and chopped before a 20 g composite root sample was processed for the extraction of nematodes by being put in a mist chamber. Five days were given for the eggs to hatch in this setup. The nematodes were collected after five days and analyzed using a stereo-binocular microscope.

***Parameters recorded*:** Data root galling index, the nematode population in soil and root, and incidence were recorded.

***Identification of Meloidogyne spp*.:** Perennial patterns were used to differentiate the several species of Meloidogyne. Selected root galls with mature females were put in Petri dishes containing tap water. Several root-knot nematode species' adult female perennial patterns were created. To remove mature females, forceps were used to rip apart root tissues. With the use of forceps, the female's neck was severed to allow the inside to be removed. The nematode's head and neck were cut off, and the rear was submerged in a 45% lactic acid solution to dissolve all body tissues. The recurring design was then cut to size and imprinted on a drop of glycerin. The identification of nematode species from each sample required the examination of at least ten perennial patterns.

***Collection of Plant material*:** Seven summer vegetable genotypes' seeds were procured from the Ayub Agricultural Research Institute, Faisalabad's Horticulture division. The seven summer vegetable genotypes—cucumber, tomato, sponge gourd, bitter gourd, eggplant, okra, and pumpkin—were included in the selection process.

Evaluation of seven summer vegetable genotypes against *Meloidogyne incognita*: In 13-cm diameter earthen pots with sterilized sandy loam soil within, seeds of seven summer vegetable genotypes—cucumber, tomato, sponge gourd, bitter gourd, eggplant, okra, and pumpkin—were planted. They were then given 25–30 days to grow. In every container, five seeds were sowed. Plant thinning was done at the five to six-leaf stage. Only one plant in the pot's middle remained after all the unnecessary plants had been removed. The remaining plants, except for the control, were removed after being infected with 2000 J2 of M. incognita per pot in the rhizosphere of each plant. These holes were then made in the rhizosphere and filled with dirt. A completely random arrangement of pots was used. Each therapy was repeated five

times. Throughout the growing phase, the temperature varied between 25 and 30 0C. Groundwater was used to quickly irrigate the pots and allow them to develop for 60 days.

***Data recorded*:** Plants were carefully removed from the containers and rinsed under running water after 60 days of inoculation. After that, the roots were damp-dried, blotted onto paper, and weighed. Carefully washing the roots removed the dirt. The cleansed roots were dyed with Phloxine B to make counting egg masses easier. Roots were submerged in a Phloxine B solution (0.15g/liter tap water) for 15 to 30 minutes (Holbrook *et al.*, 1983). After absorbing the pigment, the gelatinous matrix took on a pink to crimson hue. Eggs were removed from roots using a 1% NaOCl solution and a 250-mesh nested in a 450-mesh sieve (Hussey and Barker, 1973). Galling and egg masses were graded across the entire root system on a scale of 0 to 5 (Quesenberry *et al.*, 1989; Anwar *et al.*, 2007). Data on the number of root galls, the galling index, the number of egg masses, the egg mass index, the weight and length of the root and the shoot, the number of galls per 20g of root and 100cm3 of soil, and the reproduction factor were all recorded.

The following formula was used to calculate the reproduction factor:

$$\text{Reproduction factor} = \frac{\text{Final population of nematodes}}{\text{Initial population of nematodes}}$$

Impact of graded inoculum on reproduction of nematode and the growth of cucumber: Based on the results of the previous experiment, the most vulnerable vegetable was chosen for this experiment to examine the effects of graded *M. incognita* inoculums on plant development and nematode reproduction.

***Nematode inoculum*:** Cucumber seeds were planted in 13-cm-diameter clay pots with sterilized sandy loam soil inside of them. In every container, five seeds were sowed. Just one seedling per pot was left after 30 days of germination when the plants had grown to the 5–6 leaf stage, and all other seedlings were pulled out of the container. Tomato roots were used to gather eggs, and a 1% NaOCl solution was used (Hussey and Barker, 1973). Inoculum densities (0, 250, 500, 750, and 1000) were created by agitating egg suspension in distilled water. Making holes around the base of the plant and filling the holes with sterilized soil allowed varying inoculum densities of eggs or J2 to be injected into the pots for inoculation. The unvaccinated plants were used as the control group. Five replications of each treatment were used in the total randomized design of the pots. The sixty-day trial was conducted.

***Parameter recorded*:** After 60 days of inoculation, the effects of various *M. incognita* inoculum densities on susceptible cucumbers were assessed. The data comprised the number of J2 bacteria per 20g of the root, the number of J2/100cm3 of soil, the number of root galls, a galling index, egg masses, an egg mass index, the length of the root, and the length of the shoot. To make counting egg masses simpler, plant roots were properly cleaned to eliminate debris before being coloured for five minutes with a Phloxine B solution. The presence of galling and egg masses in the root systems was rated on a scale of 0 to 5 (Quesenberry *et al.*, 1989)

***Statistical analysis*:** Duncan's multiple range test (DMR) was performed to identify genotypes with significant differences at probability levels of P = 0.05 after data were subjected to analysis of variance (ANOVA) (Steel *et al.*, 1997).

RESULTS

***Evaluation of seven genotypes of summer vegetables against Meloidogyne incognita*:** Galls were formed by the Meloidogyne incognita on the roots of all vegetable genotypes (Table 1). Eggplant and tomato roots developed considerably (P = 0.05) more galls than the roots of all five vegetable genotypes. Statistically, the bitter gourds had the same number of galls as other vegetable genotypes, including cucumber, sponge gourd, okra, and pumpkin, but there were fewer. Cucumber, sponge gourd, okra, and pumpkin were the four vegetable genotypes with the same number of galls, although eggplant and tomato had less. Egg masses were formed by the Meloidogyne incognita on the roots of all vegetable genotypes (Table 1). Tomato roots generated considerably (P = 0.05) more egg masses per root system than the roots of the other six vegetable genotypes. The statistical number of egg masses per root system was the same for the six vegetable genotypes—cucumber, sponge gourd, bitter

Table 1. Reproduction factors and *Meloidogyne incognita's* response to seven summer vegetables

	Galls /root system	Galling index /root system	Egg masses /root system	Egg mass index /root system	Root weight (gm)	Shoot weight (gm)	Root length (cm)	Shoot Length (cm)	J2/20g root	J2/100mL soil	Rate of reproduction
Cucumber	40^{bc}	3.8^{cd}	14.0^{b}	2.7^{b}	5.4^{b}	10.9^{cd}	13.1^{c}	13.1^{c}	378^{b}	1089^{bc}	0.73^{bc}
Sponge gourd	33^{bc}	3.7^{cd}	12.8^{b}	2.7^{b}	4.6^{b}	11.2^{c}	13.1^{c}	13.1^{c}	346^{b}	900^{bc}	0.60^{bc}
Bitter gourd	26^{c}	3.2^{d}	7.3^{b}	2.0^{b}	5.8^{b}	11.6^{c}	11.7^{cd}	12.9^{cd}	198^{b}	693^{c}	0.46^{c}
Okra	55^{bc}	4.0^{bc}	7.7^{b}	2.0^{b}	3.8^{b}	12.1^{c}	10.7^{de}	11^{de}	207^{b}	1494^{bc}	0.99^{bc}
Pumpkin	55^{bc}	4.3^{abc}	9.7^{b}	2.3^{b}	4.4^{b}	11.5^{c}	12.1^{cd}	13.2^{c}	26^{b}	1985^{bc}	1.33^{bc}
Eggplant	134^{a*}	4.6^{ab}	13.8^{b}	2.5^{b}	4.4^{b}	10.4^{cd}	9.2^{de}	10^{de}	373^{b}	3623^{a}	2.42^{a}
Tomato	153^{a}	4.8^{a}	131.2^{a}	4.8^{a}	13.6^{a}	10.5^{cd}	8.8^{e}	9.9^{e}	3542^{a}	4136^{a}	2.75^{a}

Gall and egg mass indices (Quesenberry et al., 1989). Rate of reproduction = Pf/Pi (Final Population / Initial Population); * DMR Test shows that means with the same letters are not statistically different from one another at P = 0.05.

gourd, okra, pumpkin, and eggplant—but was lower for tomato. Table 1 contains information on the rate of reproduction.

Compared to the other five vegetable genotypes, the tomato and eggplant exhibited a considerably (P = 0.05) higher reproduction rate. Statistically speaking, the bitter gourd reproduced at the same rate as the other four vegetable genotypes—cucumber, sponge gourd, okra, and pumpkin—but it did so at a lower rate. The reproduction rates of the four vegetable genotypes—cucumber, sponge gourd, okra, and pumpkin—were comparable, although they were lower than those of tomato and eggplant. The tomato's root weight was substantially (P = 0.05) higher than the other six vegetable genotypes. The root weight of the other six vegetable genotypes—cucumber, okra, eggplant, bitter gourd, sponge gourd, and pumpkin—was statistically the same but differed from tomato in size (Table 1).

All vegetable genotypes showed a significant (P = 0.05) response regarding the shoot weight. Sponge gourd, bitter gourd, okra, and pumpkin were the four vegetable genotypes with considerably (P = 0.05) greater shoot weight than the other three vegetable genotypes, cucumber, eggplant, eggplant, and tomato. The shoot weights of the cucumber, eggplant, and tomato were statistically equal, but they were lower than those of the four other vegetable genotypes, including the sponge gourd, bitter gourd, okra, etc and pumpkin. All vegetable genotypes showed a significant (P = 0.05) response regarding the root length. The maximum root length of two vegetable genotypes, cucumber and sponge gourd was substantially longer (P = 0.05) than that of other vegetable genotypes, such as bitter gourd, okra, pumpkin, eggplant, and tomato. The two genotypes of vegetables, bitter gourd and pumpkin, had short roots, but statistically, they were comparable to cucumber and sponge gourd. Okra and eggplant, the other two vegetable genotypes, had short roots, but statistically, they were comparable to cucumber and sponge gourd. The lone genotype of the vegetable, "tomato," had the shortest root length but, statistically, was similar to okra and eggplant (Table 1). The maximum shoot length of the three vegetable genotypes, cucumber, sponge gourd, and pumpkin, was substantially greater (P = 0.05) than that of the tomato, okra, eggplant, bitter gourd, and other vegetable genotypes. The only genotype of the vegetable, "bitter gourd," had the shortest shoots but was statistically comparable to cucumber, sponge gourd, and pumpkin.

Okra and eggplant, two genotypes of vegetables, had the shortest shoot lengths but were statistically equivalent to bitter gourd. Tomatoes had the shortest shoots, although okra and eggplant had statistically similar minimum shoot lengths (Table 1).

All vegetable genotypes responded significantly (P = 0.05) to the quantity of soil-grown juveniles. Compared to other vegetable genotypes, such as cucumber, okra, bitter gourd, pumpkin, eggplant, and sponge gourd, the only vegetable genotype, "tomato," had a considerably (P = 0.05) higher number of juveniles in 20 g of roots. The six vegetable genotypes—cucumber, okra, eggplant, pumpkin, bitter gourd, and sponge gourd—had less young in the roots than the tomato, but their statistics were comparable. Compared to other vegetable genotypes, including cucumber, okra, pumpkin, bitter gourd, and sponge gourd, the two vegetable genotypes, tomato and eggplant, had a considerably higher number of juveniles in the soil. The four vegetable genotypes—cucumber, sponge gourd, okra, and pumpkin—had the fewest young in the soil, but statistically, they were comparable to eggplant and tomato. Bitter gourd had the fewest juveniles in the soil, but statistically, it was comparable to the four vegetable genotypes—cucumber, sponge gourd, okra, and pumpkin (Table 1).

Reproduction of m. Incognita on cucumber roots and its effect on plant growth in greenhouse: At all four nematode population densities, *Meloidogyne incognita* could develop galls and egg masses on the roots of the sensitive cucumber vegetable genotype. The GI and the number of galls varied depending on the nematode concentrations (Table 3).

Inoculated cucumber plants' roots developed galls and egg masses from the juvenile Meloidogyne incognita. Table 4 displays the data. There were significantly (P = 0.05) more galls and egg masses on the roots of cucumber plants compared to the other two inoculum levels, 1000 J2 and 750 J2 of M. incognita and 500 J2 and 250 J2 of M. incognita. The statistically same number of galls and egg masses per root system were found in the cucumber plants that received 250 J2 of M. incognita's inoculum, 1000 J2, 750 J2, and 500 J2.

Table 2. Reaction of seven vegetable Genotypes

Sr. #	Host Status	No. of genotypes	Galling index	Genotypes
1	Resistant	0	0	---
2	Moderately Resistant	0	1	---
		0	2	---
		0	3	---
3	Susceptible (S)	2	4	Bitter gourd and Sponge gourd
		5	5	Pumpkin, cucumber, okra, tomato, and eggplant

Host status = S: susceptible, root galling > 3 and root galling severity > 80; MR: moderately resistant, root galling = 1-3; R: resistant, root galling index = 0.

Table 3. Induction of root galling, galling index and eggs masses on the roots of susceptible cucumber genotype inoculated at four levels of eggs or J2 of *Meloidogyne incognita.*

Inoculum levels (Juveniles)	Root galls	Gall index	Egg masses /root system	Egg mass index	J2/20g of root	J2/100 cm^3 of soil	Root length (cm)	Shoot length (cm)
0	0^{d}	0^{d}	0^{d}	0^{d}	0^{d}	0^{d}	75^{a}	380^{a}
250	25^{c}	3^{c}	1^{d}	3^{c}	29^{c}	89^{c}	65^{ab}	371^{a}
500	97^{b}	4^{b}	2^{bc}	4^{b}	39^{b}	128^{b}	40^{bc}	295^{b}
750	138^{a}	5^{a}	3^{ab}	5^{a}	43^{a}	137^{a}	38^{bc}	283^{b}
1000	144^{a}	5^{a}	4^{a}	5^{a}	45^{a}	139^{a}	30^{c}	243^{c}

Gall and egg mass indices (Quesenberry et al., 1989). *DMR Test shows that means with the same letters are not statistically different from one another at P = 0.05.

The number of galls and the galling index were significantly (P = 0.05) greater on the 1000 J2 and 750 J2 of M. incognita-inoculated plants compared to the roots of cucumber plants that received 250 J2 and 500 J2 of M. incognita. Cucumber plants infected with 1000 J2 and 750 J2 with M. incognita produced significantly more galls on their roots than other plants (P = 0.05), and their shoot weight was lower. The plants inoculated with 250 J2 of M. incognita and the control had statistically longer branches and fewer root galls than the plants inoculated with 1000 J2, 750 J2, and 500 J2 of *M. incognita*. The cucumber plants that received 500 J2 of *M. incognita*'s inoculum had statistically greater shoot lengths and galls than those that received 1000 J2 and 750 J2 of the inoculum. Compared to cucumber plants infected with M. incognita at four different inoculum densities, the control plants had considerably (P = 0.05) longer shoot and root lengths. The cucumber plants that received 1000 J2 of *M. incognita*'s inoculum had statistically identical shoot and root lengths, but they were smaller than the cucumber plants that received 750 J2 and 500 J2 of *M. incognita*'s inoculum. The plants that received the M. incognita inoculations of 750 J2 and 500 J2 had the same shoot and root lengths but differed considerably from those that received the 1000 J2 inoculation.

DISCUSSION

It is clear that soil type or texture has an effect since it affects nematode movement. The fields with the least root-knot nematode infestation may be those with silt loam soil. In contrast to fields with low sand contents, *M. incognita* populations were frequently higher in vegetable-growing areas with higher sand percentages in the soil. The findings of this inquiry have unmistakably demonstrated that M. incognita has spread widely throughout vegetable-growing regions. Nematode feeding reduces the plant's capacity to absorb nutrients and water, which affects the yield of the crop as a whole. RKN infection is indicated by the growth of distinctive root galls on the roots of a susceptible host plant. These covert enemies are causing big losses by attacking the root system.

Moreover, bacterial, viral, and fungal diseases may be more likely to develop on injured roots. Female J2 adults develop into egg-laying adults. The nematode to which a female is a host determines how many eggs she will deposit. If a plant is a nematode host, it can be determined by the quantity of galls on the roots or the final nematode population at harvest per 20 grammes of roots. (Belair and Benoit, 1996; Jordaan *et al.*, 1988; Gast *et al.*, 1984). According to the information gathered from producers, most fields were used for vegetable farming for several years, which enhanced the root-knot nematode infection. Farmers use an intense farming technique rather than leaving the ground fallow, which encourages the growth of pests. Crop rotation in areas with sensitive crops like tomato and okra that have been afflicted with root-knot nematodes may be to blame for the high occurrence.

Different crop genotypes may also be examined for root-knot nematode infection based on the degree of root galling and the quantity of egg masses observed in plant roots. Seven summer vegetable genotypes' responses to *M. incognita* infection were examined using the development of root galling, root gall and egg mass indices, egg mass per root system, and reproduction rate.No immune genotype existed for nematode infection. Variation was seen among the seven summer vegetable genotypes examined for *M. incognita* infection. This diversity in the susceptibility of seven summer vegetable genotypes to nematode infection is normal, given that the genetic makeup of the various genotypes and cultivars of vegetables varies (Anwar and Mckenry, 2002). Although there is significant variation across the seven summer vegetable genotypes regarding many ranking characteristics, all of these are vulnerable to M. incognita infection. Because of having gall and egg mass indices of more than three and reproduction rates greater than one, all seven genotypes are vulnerable (Buena *et al.*, 2007). Meloidogyne spp., the obligatory endo-parasites, infective second-stage juveniles, penetrate the roots of the host and travel intercellularly to the vascular cylinder (Williamson and Hussey, 1996). Then, from the base of the vascular cylinder, the juveniles ascend the root. They provide long-term feeding sites in the different root zones by encouraging nuclear division without cytokinesis in the host cell. As a result of this process, enormous cells are created

that act as carbon skins. Every inoculum density revealed cucumber root proliferation. Root-knot disease in cucumbers becomes more severe as the inoculum level rises. Meloidogyne incognita inoculum concentrations of 0, 250, 500, 750, and 1000 J2/pot were examined for their effects. The four Pi (0, 250, 500, 750, and 1000 J2 or eggs per plant) of M. incognita decreased the plant growth compared to the control plants, according to cucumber host plant growth factors. It was noticed that the effect was evident on roots as well as branches. Shoot length was inversely related to root weight and inoculum levels, whereas root weight was directly proportional to inoculum levels. Research showed that root weight was not a reliable indicator of shoot growth (El-Sherif *et al.*, 2007). Compared to uninoculated plants, plant height was noticeably lower for infected plants. Increased inoculum levels induced galls to develop, which hindered the root system's ability to absorb water and nutrients and reduced shoot length, ultimately adversely affecting plant health and growth.

The pathogenicity study's findings showed that M. incognita decreased cucumber development as inoculum levels rose and therefore increased foliage growth. This resulted from the development of galls on the cucumber's root system. Due to an increase in inoculum levels, more galls developed, and the roots grew heavier. The growth of galls on its roots hampered the plant's ability to absorb water and nutrients. Reduced top growth rates appear to be significantly influenced by impaired water interactions. Additional impacts include a decrease in photosynthetic efficiency, which led to a decrease in light absorption and glucose synthesis. As a result, the plant's ability to produce more roots to get around nematode damage is also affected. Introducing nematodes into feeder roots, which produce "giant cells," may cause this detrimental effect on plant development.

The number of galls and egg masses considerably (P = 0.05) increased as the inoculum level of M. incognita per plant was raised from 750 to 1000 J2 (Yadav and Mathur, 1993). Calculating the damage produced by nematodes in terms of J2 per 20 gramme of roots and root galls was also possible, which were inversely related to inoculum levels (Hussey and Boerma, 1981). J2 per 20 grams of roots increased six times with an increase in root galls when the inoculum level was raised from 250 to 750 J2 per plant (Sable and Darekar, 1985). These results support Barker and Olthuf's (1976) and Ahmad et al. (1992) findings that nematode damage to plants was closely correlated with the populations of nematodes in the soil and the number of times they reproduced on plants.

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