# SCREENING BRINJAL CULTIVARS AGAINST ROOT KNOT NEMATODE, *Meloidogyne* spp.

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# SCREENING BRINJAL CULTIVARS AGAINST ROOT KNOT NEMATODE, *Meloidogyne* spp.

**BY**

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# CERTIFICATE

This is to certify that thesis entitled **"SCREENING BRINJAL CULTIVARS AGAINST ROOT KNOT NEMATODE, *Meloidogyne* spp. "** submitted to the faculty of agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN PLANT PATHOLOGY**, embodies the result of a piece of *bona fide* research work carried out by **Kohinoor Begum, Registration No. 06-02128** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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**Dated: 31.12.2013**
**Place: Dhaka, Bangladesh**

Dedicated To

My Parents
Who Laid the Foundation of My Success

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***The Author***

# SCREENING BRINJAL CULTIVARS AGAINST ROOT KNOT NEMATODE *Meloidogyne* spp.

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## ABSTRACT

The experiment was conducted in the net house of the Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh with thirteen brinjal cultivars namely, BARI Begun-1, BARI Begun-4, BARI Begun-5, BARI Begun-7, BARI Begun-9, BARI Begun-10, Tobla, , Irri, Deshi, Mollika, Khotkhotia, Singnath and Uttara were screened against root-knot nematode (*Meloidogyne* spp.) with a view to select resistant varieties against the pest. The highest and the lowest shoot length was found in BARI begun-7 (74.20cm) and Khotkhotia (8.40cm) respectively. The highest and the lowest fresh, shoot weight was found in BARI begun-7 (118.30g) and Deshi (2.30g). The highest dry shoot weight was found in BARI begun-7 (30.76g), and the lowest was in Deshi (0.60g). The highest root length was found in BARI begun-7 (27.60cm) and the lowest was in Deshi (7.60). The highest gall index on a 0-10 scale (Bridge and Page, 1980) was found in Deshi (9.00) and the lowest was recorded in Uttara (2.60). The highest number of egg masses per root system was found in BARI begun-10 (438.40) and the lowest was recorded in Uttara (80.80). Number of eggs/egg mass was the highest in Shingnath (503.20) and the lowest in Mollika (180.10). The highest total number of eggs/root system was found in BARI begun-5 (66.81 $x10^2$) and the lowest was in BARI begun-10 (12.94 $x10^2$). Number of J2/4 kg soil was the highest in BARI begun-7 (28.00) and the lowest was in Uttara (12.80). The highest number of nemic population/pot was found in BARI begun-4 (31.64 $x10^3$) and the lowest was in Uttara (13.10 $x10^3$). The highest number of reproduction factor was found in BARI begun-4 (31.64) and the lowest was recorded in Uttara (8.24). The highest number of galls in root system was found in Deshi (45.59) and the lowest was found in Uttara (9.81). Brinjal varieties showed variability in their response to *Meloidogyne* spp. infestation on 0-4 scale (Salawu, 1978). Deshi, BARI Begun-4, BARI Begun-10, Tobla, BARI Begun-7, BARI Begun-9, BARI Begun-5, Irri were highly susceptible with grading 4 while Khotkhotia, BARI begun-1 and Shingnath were categorized as susceptible with grading 3. Uttara was found to be moderately resistant with grading 2. None of the brinjal cultivars were found to be resistant to root knot nematode.

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# CHAPTER - I

# INTRODUCTION

# INTRODUCTION

The vegetable brinjal, *Solanum melongena* L. is the second most important vegetable crop next to potato in Bangladesh in respect of acreage and production (BBS, 2005). The total area of brinjal cultivation was 28815.69 ha with 7 707.21 kg/ha yield and total production of 222110 metric.tons in winter season and 17812.27 ha with 6227.06 kg/ha yield and total production of 110910 metric tons in summer (BBS 2007).

In Bangladesh brinjal is being cultivated in almost all districts and consumed as a cooked vegetable in various ways. It is grown at homestead area and kitchen garden because of its popularity especially to the urban people. There are several varieties of brinjal grown in Bangladesh such as, Kazla, Jhumka, Nayantara, Islampuri, Uttata, Luffa (Elongated), Luffa (Black), Luffa (White), Luffa (BAU), Luffa (Oblong), Bholanath, Dohajari, ISD-006, Dhundul etc. All the varieties are not high yielding. Some of high yielding varieties found to be cultivated are BARI Bagoon-2 (Tarapuri), BARI Bagoon-4 (Kajla) and BARI Bagoon-5 (Nayantara). About 8 million farm families are involved in brinjal cultivation (Islam, 2005). This gives small, marginal and landless farmers a continuous source of income and provides employment facilities for the

rural people. For most of the times, market price of brinjal remains high compared to other vegetables in the market. In Bangladesh root knot may cause up to 27 % loss in fruit yield in brinjal (Bari, 2001).

In Bangladesh, production and quality of eggplant are reduced by a number of pathogens and pests including Phytoparasitic nematodes (Timm and Ameen, 1960; Talukdar, 1974; Page, 1979; Ahmed and Hossasin, 1985; Mian, 1986.) Most of plant parasitic nematodes live in the soil, they represent one of the major pest problems to identify, demonstrate and control (Stirling *et al.*, 1991). Their effects are commonly underestimated by farmers, agronomists and pest management consultants, but it has been estimated that 10 percent of world crop production is lost as a result of plant nematode damage (Whitehead, 1968). Among the root-knot nematodes (*Meloidogyne incognita* (Kofoid and white) Chitwood and *Meloidogyne Javanica* (Kofoid and white) Chitwood are considered to be the major nemic pests of the crops (Timm and Ameen, 1960; Mian, 1986; Mian and Tsuno, 1988). Several species attack Poaceae in cool climates, including *M. artiellia*, *M. chitwoodi*, *M. naasi*, *M. microtyla* and *M. ottersoni* . In warm climates, *M. graminicola*, *M. graminis*, *M. kikuyensis* and *M. spartinae* are important (Taylor and Sasser, 1978). Root-knot nematode larvae infect plant roots causing the development of giant cells, root galls through hypertrophy

and hyperplasia. The giant cells and galls disrupt uptake of nutrients and water and interfere with plant growth (Sasser 1980, Sasser and Carter, 1985). Infection of young plants may be lethal, while infection of mature plants causes decrease in growth yield (Stirling *et al.*, 1992).

The above ground symptoms caused by root knot nematodes are very general like other soil borne pathogen, mineral deficiency, stunting growth, wilting, patches in the field and decline in fruit production, quality and quantity (Sikora and Fernandez, 2005). Infested plants are generally unhealthy but in favorable growing conditions may tolerate attack, especially with partial damaged root system (Evans *et al.*, 1993). The belowground system includes swelling and galls throughout the root system and under the severe attack the plant may die. Nematodes produce multinucleate giant cells by injecting secretions in to the root cells which provide a continuous source of food to the nematode. Root galls vary in size and shape depending on the type of plant, nematode population levels, and species of root-knot nematode present in the soil (Sardanelli, 2010). Root-knot nematodes are major pathogens of vegetables, impacting both quality and quantity of marketable yields. In addition, root-knot nematodes interact with other plant pathogens, resulting in increased damaged caused by other disease (Taylor and Sasser, 1978; Widmer *et al.*, 2011).

Root-knot nematodes have been identified as the most economically damaging plant-parasitic nematodes because of their wide host range and widespread distribution throughout the world (Riedel *et al.*, 2011). Root knot nematodes cause approximately 5% crop loss globally including advanced countries. In vegetables the loss is very high. Yield reduction due to root knot nematode has been estimated 25% in potato (Ahmed and Hossain, 1985), 37-47% in tomato (Darekar and Mhase, 1988) and in brinjal 53-63% (Winstead and Kelmann, 1960). Root knot nematode is the most important plant parasitic nematodes in Bangladesh (Timm and Ameen, 1960; Talukder, 1974). At least four species of root knot nematodes are associated in occurring root knot in different crops in Bangladesh. They are *Meloidogyne incognita, M. javanica, M. graminicola and M. arenaria* among which, *M. incognita* is most frequently occurring plant parasitic nematode (Mian, 1986).

There are some experiments recently conducted which are related to screening program with different crops along with *Meloidogyne* spp. to find out their resistant varieties. These are, screening of 18 okra germplasm and 3 cultivars for their resistance to *M. incognita* under greenhouse conditions. It reported that no cultivar or germplasm was resistant. AROH-10, HOE-202, VLC-1, AROH-9, VB 9101, IIHR-91,

and Arka Anamika were susceptible, whereas the rest were highly susceptible (Rekha and Gowda, 2000).

Five sunflower cultivars i. e. FH-75, Beimisal-205, Hysin-33, Super-25 and Engro 9704 were tested for screening. FH-75 proved the most tolerant against root knot nematode infestation. It gave minimum reduction in plant height and minimum increase in fresh and dry root weight. The varieties BEIMISAL-205, Hyson-33, Super-25 and Engro-9704 exhibited tolerance respectively. Engro-9704 was the most susceptible variety to root knot nematode infestation (Rehman *et. al.*, 2006).

Another screening trail conducted with five cultivars of chilli, *Capsicum annuum* for resistance against *Meloidogyne incognita* in pot experiments. Three-week-old seedlings were inoculated with 1000 freshly hatched juveniles of *M. incognita*. Ninety days after inoculation the plants were uprooted and examined for galls, root and shoot lengths, fresh/dry root and shoot weights. The cultivar Pusa Jwala was assessed as moderately resistant with the minimum number of galls and variety PC-1 was highly susceptible developing the maximum number of galls. All the other varieties exhibited variable degree of susceptibility between Pusa Jwala and PC-1 (Malhotra *et. al.*, 2012).

Due to worldwide distribution, affinity with other pathogens and serious destruction to vegetables and field crops, it is necessary to find out the most effective and feasible management of root knot nematodes. Among different nematode management strategies, chemical control has proved generally effective (Barker and Koenning, 1998) but being highly expensive, toxic to plants, livestock, soil micro-flora and fauna (Jairajpuri *et al.*, 1990), removal of key nematicides from the market (Veremis and Roberts, 1996) and development of resistance in pathogen against these chemicals, governments today demand environmentally safe chemicals with low toxicity, short term persistence, low mobility to avoid ground water contamination and limited effects on non-target organisms. Therefore, the development and implementation of alternative control strategies are needed.

Under above circumstances the present piece of research was undertaken with the following objectives:

1. To screen some brinjal cultivars for resistant to root knot nematode, *Meloidogyne* spp.

# CHAPTER – II

# REVIEW OF LITERATURE

# REVIEW OF LITERATURE

## 2.1. Evidences of root knot nematode

Root-knot nematode *Meloidogyne* is the most abundant and widely available in Bangladesh (Timm and Ameen, 1960 and Ahmad, 1977). Moreover, the nematode population in the soils of Bangladesh is increasing day by day (Choudhury, 1981). In Bangladesh, root-knot disease ranks as one of the most important disease of nematode caused by *Meloidogyne incognita* and *Meloidogyne javanica*. They attack wide variety of the field, fruit and vegetable crops including brinjal (Biswas, 1979). In certain crops, the loss is increased because root-knot predisposes the plants to injure by other disease (Chester, 1950).

Berkeley (1855) discovered the root knot nematode *Meloidogyne* spp. on cucumber in a greenhouse for the first time in England. It has a broad host range including vegetables, field crops and trees. According to Mehrotra (1983) root-knot nematode *(Meloidogyne* spp.) is the most important and dominant group of plant parasitic nematodes found almost in all vegetable growing areas and enormous losses are caused due to the nematodes.

According to Pelekassis (1979) root-knot nematodes as the most abundant and destructive group infected 90 plant species in Greece including eggplants, tomatoes, cucurbits, cabbage, tobacco, sugar beet, several fruit trees and others the most important economic plants. *M. javanica, M. incognita* and *M. arenaria* were found in the most of samples.

In Iran, Abidvardi *et al.* (1979) collected 95 samples from 207 villages of Far Province and found root knot nematodes in all districts of province at infestation rate of 38% in country. *M. javanica* (78%) was the most widely distributed species followed by *M. incognita* (17%) and *M. hapla* (5%) which was found only in one district.

Hassan and Yuksel (1979) studied the distribution of *Meloidogyne* spp. in Turkey. *M. incognita* was mostly found in North Anatolia because temperature and precipitation favored survival as compared to other species. *M. incognita, M. javanica, M. arenaria, M. acrita*and *M. hapla* were present in different ecological conditions except cold climate of Erzurum.

Root knot is a major nemic disease not only in Bangladesh but also in other countries of the world like Srilanka, Philippines, Pakistan, India and

where ever brinjals are produced. This disease is caused by nematodes of *Meloidogyne* spp. and also some other nematodes like *Pratylenchus* spp, *Helicotyenchus* spp, are associated with root of brinjal.

**2.2. Symptoms of root-knot disease of brinjal plant**

The soil and climatic condition of Bangladesh has made her an ideal abode for nematodes. A preliminary survey found 15 genera of plant parasitic nematodes associated with commercial crops in vegetable production.

Agrios (2005) reported that characteristics symptoms of the disease appear on the underground parts of the plants. Infected root swell at the point of invasion and develop in to the typical root-knot gall that are two to several times as large in diameter as the healthy root. Several infection take place along the same root, and the developing galls give the root a rough, clubbed appearance. Roots infected by certain species of the nematode develop in addition to galls, several short root branches that rise from the upper part of the gall and result in a dense, bushy root system.

Mian (1994) reported that due to attack of root-knot nematodes, the cell walls closest to the nematodes head become increased in size, or

hypertrophic. The abnormally large cells induced by root-knot nematodes. Infected roots with hyperplastic tissue have bulbous swelling and appear distorted.

Hasan (1991) reported that the most distinctive symptoms of root-knot are the galls on the root. The galls vary in size from a pin head to many times the thickness of the root on which they grow. In shape they are irregular, spindle sharped or spherical. Although the knots may be scattered on any part of the main root or its branches, they are most often found on tender root lets, resembling beads on a string. Sometimes the galls are so close together that they appear to be single elongated gall. Sometimes, root proliferates and form like a witchs broom.

Nassar and Mustafa (1981) inoculated 22 days old tomato plants with *Meloidogyne hapla* and *M. arenaria* at the rate of 100 to 1600 per 1500 $cm^3$ soil which produced heavy galls with a little effect on plant growth.

Ogunfowora (1977) found that yield of different tomato cultivars was considerably reduced at different inoculum levels of *Meloidogyne incognita*. 10% yield loss was caused by pre plant populations.

Root-knot caused by *Meloidogyne incognita* is important and widely distributed disease in the country (Talukder, 1974; Ahmed and Hossain,

1985 and Mian, 1986). The nematodes are soil borne roundworms that attack the root system of brinjal plant.

Wong and Mai (1973) studied the pathogenicity of *Meloidogyne hapla* to lettuce at different inoculum levels, plant age and temperature. Shoot weight of inoculated plants with five egg masses at 1-2 week was reduced up to 32%. Shoot weight was not affected significantly at higher inoculum level.

**2.3. Pathogenic description of *Meloidogyne* spp.**

*Meloidogyne* spp was found to be associated with root knot in different countries in the world. *M. incognita, Xiphinema compinenese* and *X. krugi* was found in *Prunuspersica* in Brazil by Lordello and Zamith (1960).

79% of the samples infected with root knot nematodes were reported by Tarjan (1964) and later by Ibrahim *et al.* (1976) in northern Egypt.

*M. hapla* (48.3%) the most dominant followed by *M. incognita* (38.0%) and *M. javanica* (5.7%) in eggplant, soya bean, peanut, tomato, cucumber, carrot, watermelon, ginseng, red pepper, tobacco, strawberry, cabbage, lettuce and ginger in seven provinces of Korea was reported by Choi (1976).

Formation of galls on the infected roots was reported as primary symptom of *Meloidogyne* spp. as the result of severe attack, vascular system of root completely disorganizes with almost absent rootlets with seriously malfunctioned uptake and transportation of water and nutrition. Wilting and stunted growth under dry condition was reported by (Linford, 1941)

Root-knot nematodes may pose a serious threat to brinjal which resulting in poor growth and reduced productivity (Sitterly and Fassuliotis 1965). It has been reported that the yield reaction may be upto 25% under severe infestation (Mendoza and Jatala, 1978).

Hillocks and Waller (1997) reported that, sedentary endoparasitic nematodes such as the root-knot nematodes (RKN) (*Meloidogyne* spp.) enter into the root and move through the cortex to the vascular system, where they begin to feed and remain to complete the life cycle. In general, the sedentary endoparasitic have the most profound effect on disease susceptibility. The cortical feeding nematodes may predispose the root to infection but the effect is localized, providing entry sites for pathogens or increasing nutrient leakage.

Singh and Sitaramaiah (1994) stated that, root-knot nematode *Meloidogyne* spp. are the first plant parasitic nematode to be recognized. The mature female of *Meloidogyne* spp. are swollen, pear or subspherical in shape. They are sedentary endoparasities. The body remains soft, white and does not form a cyst. Female stylet is slender with well developed basal knobs. First moult occurs within the egg. Males are vermiform and migratory. Second stage juveniles are vermiform, migratory and infective. Third and fourth larval stages are swollen.

**2.4. Screening of brinjal cultivars against root knot nematodes**

Cultivation of resistant varieties can be used for controlling root-knot nematodes successfully if such varieties are available (Windslow and Will, 1972).

In Bangladesh, resistant variety of brinjal against root-knot nematodes has not yet been developed. Moreover, in case of brinjal attempts to develop such varieties are limited.

A series of experiments has been conducted at central Research station of BARI, Joydebpur, Gazipur to screen Brinjal varieties against root-knot nematodes *Meloidogyne* spp. under field condition. Many varieties and lines were included in those screening tests and their reactions to the pests

were reported to be variable in different years. Same varieties were graded as highly susceptible, susceptible, tolerant or resistant because their reactions to the nematodes, in terms of gall development varied with the test season. The varieties were graded as Immune, Highly Resistant, Tolerant, Susceptible and Highly Susceptible on the basis of gall index values (Anon., 1981; 1982; 1983; 1985; 1986; 1990; 1992; 2000; 2002).

Thirteen brinjal varieties were screened against the pests *Meloidogyne* spp. at the central Research station of BARI. Among them Baromashi, Bhagar, Black beauty, D.R. Choudhury, japani, khotkhotia, singhnath and White jumki were Susceptible, whereas Bakuli, Early Prolific, Islampuri, Mukhtakeshi and Nayankazal were graded as highly susceptible (Anon. , 1981).

In a field screening program six varieties of brinjal namely Muktakeshi, white jumka, jumka, D.B. Choudhury, Longla and Baramashi were tested against *Meloidogyne* spp. and three varieties namely White jumka, Jumka and D.R. Choudhury were screened as resistant, two varieties were susceptible and one variety was tolerant to the disease (Anon., 1982).

In a field trial Rajshahi-9, Black king, Rajshahi-14, Islampuri, Nayankazal were found susceptible, purple king as resistant and Rajshahi-11 as tolerant (Anon., 1983).

Test with 8 different verities of bringal seedlings namely Islampuri, rajshahi-9, Shingnath, khotkhotia, shingnath long, Rajshahi-8, Pusakanti, rajshahi-6 at the flowering stage of the plants disease was estimated through root damage by *Meloidogyne* spp. and two varieties were Islampuri and Rajshahi-8 found to be tolerant. The rest of the varieties were susceptible and highly susceptible. (Anon., 1985).

After observing eight brinjal varieties- Rajshahi-9, Pusa purple long, Rajshahi-3, shingnath-1, khotkhotia long, Rajshahi-6, shingnath long, Islampuri for *Meloidogyne* spp. one was found immune or resistant to root knot while Rajshahi-9, Pusa purple long, Rajshahi-3 were tolerant and the rest of the varieties were susceptible and highly susceptible. (Anon., 1986).

Among 13 varieties of brinjal cultivars namely Rajshahi-9, pusa purple long, D.R. Chowdhury, White jumka, MuktaKeshi long, Black king, Rajshahi-14, Islampuri, Nayankazal, longa, Black beauty, Rajshahi-2, Muktakeshi roundit was found that three varieties namely Rajshahi-9,

pusa purple long, D.R. Chowdhury were tolerant, six varieties namely White jumka, MuktaKeshi long, Black king, Rajshahi-14, Islampuri, Nayankazal were susceptible and three varieties namely Black beauty, Rajshahi-2, Muktakeshi round were highly susceptible (Anon., 1986).

Result a recent test indicates that Black beauty was moderately resistant, one line was susceptible and other varieties/lines including Shingnath were highly susceptible (Anon., 1990).

Fifty nine Tomato and thirteen Brinjal varieties / lines were screened against root-knot nematode *Meloidogyne* ssp. both under field and pot conditions at BARI, Gazipur. Seeds and seedlings of all the crops varieties/lines were sown/transplanted in nematode infested pots and field simultaneously. The root systems of all the varieties were indexed for degree of galling and disease reaction. Among the lines tested three tomato varieties namely TM-177, TM-413 and BCC showed highly resistant, Brinjal variety *Solanum turvum* was not infested, *S. sisymbrifolium* showed highly resistance and rest were susceptible to highly susceptible (Anon., 1992).

In Screening of seventy germplasms of eggplant received from Horticulture Research Center, BARI the root systems were indexed for

galls following 0-10 scale. None of the germplasms was found resistant, 4 of them (BL 111, 156, 97 (2) and ISD 06) were moderately resistant while 36 were susceptible and rest were highly susceptible to root knot nematode. (Anon., 2000).

Study with 34 germplasms of eggplant against root-knot nematode was conducted at BARI, Joydebpur and Gazipur during Rabi season. One-month old seedlings of the test germplasms were transplanted in three replications in RCB design in sick bed, having population of 4500-5000 root knot nematode larvae/kg soil. Results showed that among 35 germplasms, only 7 were found moderately resistance and the rest gave susceptible reaction to root knot nematode. The shoot height ranged from 31.90 to 45.17 cm. the highest shoot height was recorded in BL 156 (III) and lowest in BL-SI. The variation of shoot weight was recorded in BL 156 (III) and the minimum in long purple. The lowest gall indexing value was recorded in BL-97 and BL-102 followed by 156 (II), BL-122, BL-122, BL-009, BL 146 (III) and BL S1(S)1, respectively, whiles the highest in S00128. (Anon., 2002).

Kandokavo (1977) found that out of 18 cultivars of tomato Ronita, Perita, Matoba, Monita, Matsol, Nema cross, Katala, Nemared and G. 370 were resistant to *Meloidogyne* spp.

Rao and Singh (1977) tested 34varieties of okra against *Meloidogyne incognita* for their susceptibility to root-knot and they found all the varieties to be susceptible to same degree.

Mahajan and Sharma (1979) screened numerous okra cultivars and lines for resistance to *M. incognita* in field studies between 1975 and 1979. Only cv. Abtalia (from Iraq) was found to be slightly susceptible. The remaining lines and cultivars were either susceptible or highly susceptible.

Abu-Gharbieh and Maisarah (1979) observed that among the cultivars and lines of eggplant tested for resistant to *Meloidogyne javanica* under greenhouse condition showed that eggplant cultivars Baren FI/ clause and Blank beauty/ Abundance infected severely while Black Beauty/ Tezier, Special Hilbush/ Asgro, Viscerba 77357/Asgrow and Large Black were moderately susceptible and some are seemed to be least susceptible.

Eissa *et al.* (1979) from a pot experiment reported that out of 29 different cultivars of tomato tested against *Meloidogyne incognita* Race II, they showed slightly susceptible, moderately susceptible and highly susceptible type of reaction.

Kuriyan and Seshardi (1980) from India found that of 323 varieties of tobacco screened against *Meloidogyne incognita* and *Meloidogyne javanica,* 3 Motihari varieties were found to be moderately resistant, *Nicotiana repanda* did not show any root galling indicating highly resistant.

Barbara (1981) while conducted a screening experiment with 17 lines of tomatoes showed that none of the 17 cultivars were resistant except line AT- 70/24 which showed some resistant while the lines super California was found moderately susceptible.

In a screening trial of 29 cultivars of tomato, 15 of brinjal and 9 of okra, none of the cultivars were found resistant to *Meloidogyne* spp. Choudhury, B. C. (1981).

Charas and chumram (1981) while screening one hundred twenty two lines and varieties of tomato against *Meloidogyne incognita* showed that four lines including the breeding line kewalo and L 274 was found resistant.

Toshio *et al.* (1981) conducted a screening experiment with 408 clones of sweet potato on the basia of visul root-knot reading of the test plant based on following five class 0. all roots, without visible galls; class 1, 1

to 25%, class 2, 26-50%, class 3, 51-755 and class 4, 76-100% of roots with galls showed that out of 408 clones, 67 possesses high resistance and another 66 clones showed some resistance.

Fassuliotis (1981) further reported that root-knot response can be evaluated on the basis of galling by a 0-5 galling scale. These would correspond numerically as: R= 0-1, I= 2-3, S= 4-5, (R= Resistant; I= Intermediate and S= Susceptible).

Jain *et al.* (1983) evaluated 30 germplasms of eggplant for their resistance to *Meloidogyne javanica* and found that entries S-1, S-5, Aushey, Panipat selection, No. 2, T-3, PH-4, Sel-2, Pusa purple Long, Black round, Panipat, Kalyanpur T-2, shankerVijaya, White Long, Sel 2-1, S-4, s-373, Sel 1-1-1, PanipatBaha, s-3, 6-373, Pusa Purple Round and Arka-kusumakar were slightly resistant and r-4, *Solanum sisymbriifolium*, Mysore green, BR-112, American Big Round, Arkasheel and sonepat selection were moderately resistant.

Ali *et al.* (1990) evaluated resistance of eggplant and its wild relatives and found that in *S. kashianum, S. torvum* and *S. toxicarium, S. integrifolium* was susceptible. *S. indicum* and *S. surattense* were highily

susceptible. Small swellings were formed in *S. sisymbriifolium* but the nematode failed to develop and reproduce in its root systems.

Ahmad *et al.* (1992) reported that all tomato cultivars inoculated with root knot nematodes produced knots to various extents. Long tipped variety was found highly susceptible, Roma resistant and Money maker was moderately resistant.

Anwar and Khan (1992) studied the response of brinjal, chili, tomato and okra to RKN at 10,000 inoculum level. None of them was found immune or resistant. The brinjal cultivar Moneymaker was highly susceptible whereas chili, tomato and okra were highly susceptible. Similar, results were achieved on, brinjal having susceptibility to *M. incognita* and *M. javanica* (Soomro *et al.*, 1993).

Hazarika *et al.* (1995) screened 45 brinjal cultivars in pot experiments and found none of them resistant to root knot nematodes.

Sharma and Singh (1996) tested 10 okra varieties against *M. incognita* and found all of them to be susceptible.

Das *et al.* (1997) screened 16 coriander 22 (*Coriandrum sativum*) genotypes for reaction to *M. incognita* and classed $CO_2$ and UD21 as

resistant, whilst RCr41, UD20, Co1 and $CO_3$ were moderately resistant and 10 other varieties were classified as susceptible.

Han and Kim (1997) bioassayed 175 red pepper varieties for selecting resistance to *M. hapla*. Fifteen native varieties (IT 102794, 104806, 105516, etc. and two imported varieties were proved to be resistant while the varieties such as Hongtap, Kangsan, Hongsil, and Bookang were moderately resistant to the nematodes.

Pinochet *et al.* (1998) tested 15 accessions and cultivars of banana for their resistance towards *Pratylenchus goodeyi, M. incognita* and *M. javanica* and found that most of the tested material was highly susceptible to all the three nematodes.

Chavda *et al.* (1999) observed that of 25 green gram (*Vigna radiata*) lines, variety IC 10488 was highly resistant to *M. incognita* but highly susceptible to *M. javanica*. IC 8955 and IC 11438 showed moderate susceptibility to *M. javanica*. The remaining lines were either susceptible or highly susceptible to both the species of root-knot nematodes.

Debanand (1999) noticed that out of 25 rice cultivars screened against *M. graminicola*, only MTC 23/A showed any resistance.

Rekha and Gowda (2000) screened 18 okra germplasm and 3 cultivars for their resistance to *M. incognita* under greenhouse conditions. No cultivar or germplasm was resistant. AROH-10, HOE-202, VLC-1, AROH-9, VB 9101, IIHR-91, and Arka Anamika were susceptible, whereas the rest were highly susceptible.

Fazal *et al.* (2001) evaluated 34 soybean cultivars for their resistance to *M. incognita* and found that 18 were resistant, 5 were moderately resistant, 5 were susceptible and 7 were highly susceptible to *M. incognita*.

Aparajita *et al.* (2004) evaluated a total of 282 genotypes of green gram for resistance to *M. incognita*. Seventy-four genotypes were found to be susceptible while the rest of the genotypes were highly susceptible.

Pathan *et al.* (2004) studied the response of seven tomato cultivars against *M. incognita*. None of the variety was found immune to *M. incognita.*

Choudhury *et al.* (2005) screened 149 cultivars of cowpea for their resistance against *M. incognita* and found that 19 were resistant, 42 were moderately resistant, 61 were susceptible and 27 were highly susceptible to the nematode.

Bibha and Bora (2005) tested 20 jute cultivars for resistance to *M. incognita* and found them either susceptible or highly susceptible.

Adegbite*et al.* (2006) studied the cowpea varieties ten weeks after planting from randomly selected plants for root-galls and nodules. Root-galling varied significantly.

Khan *et al.* (2006) studied the percentage incidence of root-knot nematodes affecting Tomato in different districts of Faisalabad and Lahore divisions. The maximum Infection of 69.23% in district Okara of Lahore division followed by 65.79, 64.0 and 63.63% in Faisalabad, Toba Tek Singh and Jhang districts of Faisalabad division, respectively was recorded. Minimum infection of 55.55% was recorded in Sheikhupura. The infections recorded in Lahore and Kasur districts were 60% and 56.25% respectively. None of the 15 tomato cultivars was immune or resistant. Cultivars Moneymaker, Pakit, Pasestter, Chico, Peelo, Titano, Riogrande, Savio, Shadylady and Nagina were found highly susceptible, Marrchia, UC-134 and Areletta, were susceptible while the other two cultivars UAE-1 and Roma were rated as moderately susceptible.

Rehman *et. al.* (2006) tested five sunflower cultivars i.e. FH-75, Beimisal-205, Hysin-33, Super-25 and Engro 9704 for screening. FH-75

proved the most tolerant against root knot nematode infestation. It gave minimum reduction in plant height and minimum increase in fresh and dry root weight. The varieties BEIMISAL-205, Hyson-33, Super-25 and Engro- 9704 exhibited tolerance respectively. Engro-9704 was the most susceptible variety to root knot nematode infestation.

Malhotra *et. al.* (2012) screened five cultivars of chilli, *Capsicum annuum* for resistance against *Meloidogyne incognita* in pot experiments. Three-week-old seedlings were inoculated with 1000 freshly hatched juveniles of *M. incognita*. Ninety days after inoculation the plants were uprooted and examined for galls, root and shoot lengths, fresh/dry root and shoot weights. The cultivar Pusa Jwala was assessed as moderately resistant with the minimum number of galls and variety PC-1 was highly susceptible developing the maximum number of galls. All the other varieties exhibited variable degree of susceptibility between Pusa Jwala and PC-1.

# CHAPTER – III

# MATERIALS AND METHODS

# MATERIALS AND METHODS

## 3.1 Experimental period

The experiment was carried out during the period from June 2012 to September 2013 in the laboratory and net house of the Department of Plant Pathology, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207.

## 3.2 Pot experimental site

The experiment was conducted in a net house at the department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka.

## 3.3. Climate

The climate of the experimental area was of sub-tropical in nature characterized by high temperature associated with heavy rainfall during Kharif season (April to September) and scanty rainfall with moderately low temperature during Rabi season (October to March).

### 3.4. Treatments of the experiment

There were thirteen brinjal cultivars were used as treatments in the experiment which are as follows:

$T_1$ = BARI Begun-7

$T_2$ = BARI Begun-9

$T_3$ = BARI Begun-10

$T_4$ = BARI Begun-4

$T_5$ = Tobla

$T_6$ = BARI Begun-5

$T_7$ = Irri

$T_8$ = Deshi

$T_9$ = Mollika

$T_{10}$ = BARI Begun-1

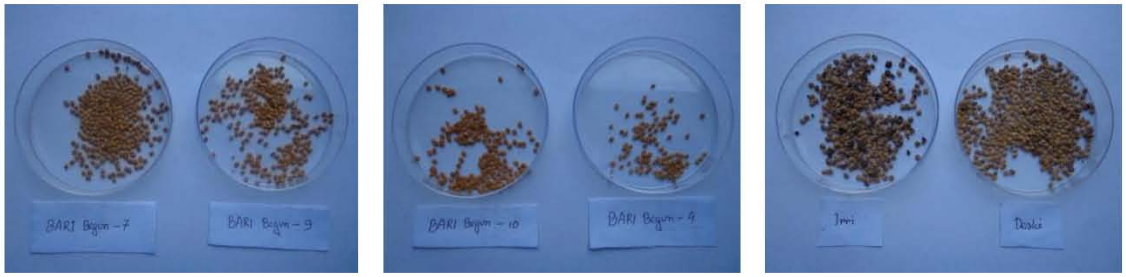
$T_{11}$ = Khotkhotia

$T_{12}$ = Singnath

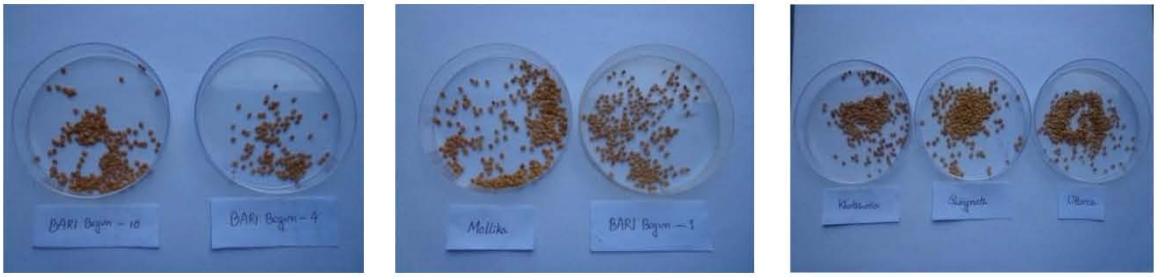
$T_{13}$ = Uttora

### 3.5. Collection of seeds

Healthy, mature and disease free farmers' seeds of different brinjal varieties were collected from different region in Bangladesh (Plate 1), such as Singnath from Mymensingh; Khotkhotia from Jamalpur; Tobla, Irri and Deshi from Iswordi; Uttora from Madaripur and Mollika from Rajshahi and released seeds (BARI Begun-1, BARI Begun-4, BARI Begun-5, BARI Begun-7, BARI Begun-9, BARI Begun - 10) from Bangladesh Agricultural Research Institute (BARI).




(a) (b) (c)




(d) (e) (f)

**Plate 1. Seeds of brinjal varieties, used in the experiments**
**(a) Begun -7 and BARI Begun -9**
**(b)BARI Begun -10 and BARI Begun -4**
**(c)Irri and Deshi**
**(d) BARI begun – 10 and BARI begun - 4**
**(e) Mollika and BARI Begun -1**
**(f) Khotkhotia , shingnath and Uttora**

### 3.6. Raising of seedlings

Plastic trays were filled up with fertile soil presterilized in autoclave. Seeds of brinjal cultivars were soaked in water for 24 hours. Then the seeds were sown in plastic trays containing sterilized soil. The trays were covered with polyethylene sheet and kept under the sunlight for raising seedlings (Plate 2). Seedlings were observed regularly and watering was done as per necessary up to 1 month and 10 days until transplanting in experimental earthen pots.


(a) (Treatment-1)


(b) (Treatment-2)


(c) (Treatment-3)


(d) (Treatment-4)


(e) (Treatment-5)

(f) (Treatment-6)


(g) (Treatment-7)


(h) (Treatment-8)


(i) (Treatment-9)

(j) (Treatment-10)


(k) (Treatment-11)


(l) (Treatment-12)


(m) (Treatment-13)

**Plate 2. Raising of brinjal seedlings in seed bed on plastic trays.**
**(a) BARI Begun-7 (b) BARI Begun-9, (c) BARI Begun-10, (d) BARI Begun-4, (e) Tobla, (f) BARI Begun-5, (g) Irri , (h) Deshi (local cultivar), (i) Mollika, (j) BARI Begun-1, (k) Khotkhotia, (l) Shingnath, (m) Uttora.**

### 3.7. Preparations of pots

Soil was collected from the experimental fields of Sher-e-Bangla Agricultural University and mixed with sand and cowdung properly in a ratio of 6:2:1.Soil was dripped with 40% formalin solution and kept covered with polyethylene sheets for 2-3 days. Then the soil was uncovered and pulverized enough and kept for two days to release the gas of formalin. Sterilized soil was dispensed at the rate of 4 kg per pot. Then the pots were arranged according to experimental design.

### 3.8. Nematode culture

Nematode samples (*Meloidogyne* spp.) were collected from nematode infected brinjal root. Egg mass were picked up and inoculated in young seedlings of brinjal. Sub-culturing was done subsequently by inoculating new brinjal seedling with egg masses (Figure 1).

**Figure 1. Photograph showing stock culture *Meloidogyne* spp for inoculation.**

### 3.9. Design and layout of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) with eight replications of each treatment.

### 3.10. Transplanting of seedlings

Forty days old seedlings were uprooted carefully from the plastic trays and only one plant was transplanted to each pot in the net house (Figure 2). Sufficient irrigation was given just after transplantation. Watering was continued till the seedlings were established.


**Figure 2. Photograph showing transplantation of plant in pot.**

### 3.11. Inoculation of *Meloidogyne* spp.

Mature egg masses of nematode (*Meloidogyne* spp) were collected from severely galled roots of brinjal. The number of eggs per egg mass was counted. Each plant was inoculated with 10,000 eggs at ten days after transplantation (Plate 3).

**Plate 3. Collection of egg masses and inoculation of eggs of *Meloidogyne* sp.**

### 3.12. Intercultural operations

Weeding and irrigations were done after transplantation of seedlings. The plants were observed regularly. General sanitation was maintained throughout the growing period. Insecticide named marshal was sprayed 5 times at 15 days intervals to protect the crop from aphid, mealy bug and white fly and shoot borer infestation.

### 3.13. Harvesting and data recording

Two months after transplanting, the plants were harvested and data were recorded. The following parameters were considered for data collection.

1. Shoot length
2. Shoot weight (fresh and dry)
3. Root length
4. Root weight (fresh)
5. Number of leaves/plant
6. Gall index (0 – 10)
7. Number of galls/root system
8. Number of egg masses per root
9. Number of eggs per egg mass
10. Number of eggs per root system
11. Number of juveniles per 100g soil
12. Number of juveniles and eggs per 4kg soil (per pot)
13. Reproduction factor

### 3.14. Data recorded

#### 3.14.1. Plant data collection

Before harvest, the shoot length was taken by measuring the height (cm) from the base of the plant to the growing tip of the youngest leaf. Then the plants were uprooted soil was separated very gently from the roots and washed free of soil. Then the clean roots were kept in different polyethylene bags, which were leveled according to different treatments (varieties). The length of root (cm) was taken by measuring from the growing point of root to the longest available lateral root apex. For fresh weight of root and shoot the portion were dried with blotter paper and the weighted. Dry weights of shoots were recorded after oven drying of shoots at 70˚c for 72 hours.

### 3.14.2. Counting of nematode egg masses/root system

Roots were collected and properly washed with water in such gently that no egg mass could be washed out. Following Holbrook *et al.* (1983) the number of egg masses/root system was counted after soaking the roots in phloxine-B (2mg/l) for 15 minutes (Hartman and sasser, 1985). Then the water was soaked with the help of a tissue paper for a minute (Plate 4). Egg masses/root system was counted with the help of a magnifying glass.


(a) (b)

**Plate 4. Photograph showing (a) infected roots treated by Phloxine- B solution and (b) stained egg masses on roots.**

### 3.14.3. Slide preparation and counting of nematode eggs/egg mass

Three drops of glycerin was taken on a glass slide. With the help of a fine pointed forceps one egg mass collected from pretreated root with Phloxine-B (2mg/l) was taken on slide. The egg mass was crashed with the bottom of a needle. After placing the cover slip the slide was examined under compound microscope and eggs/egg mass was counted (Figure 3**).** Eggs from randomly selected 10 egg masses were counted then the average was taken.

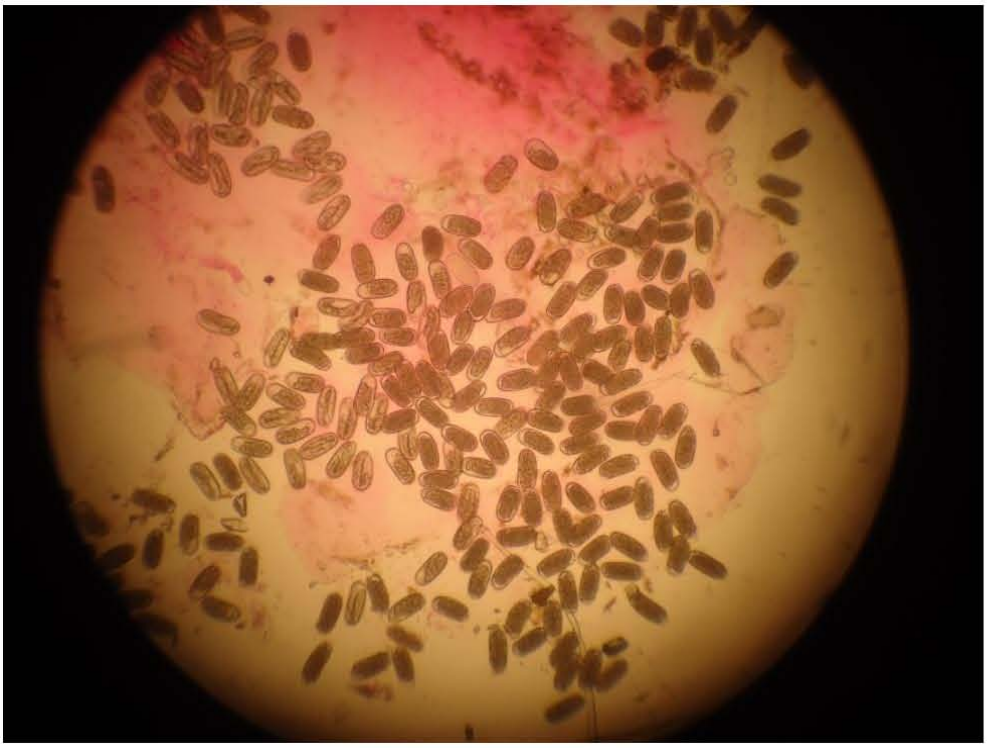


**Figure 3. Photograph showing eggs of *Meloidogyne* sp. under compound microscope (10x).**

(B) (C)

**Plate 5. Photograph showing adult female (A) and second stage juvenile of *Meloidogyne* spp. (B).**

### 3.14.4. Extraction of nematode from soil and counting of juveniles

Juveniles were collected following Whitehead and Hemming tray method (1965). A sieve on a bowl was taken. A piece of kitchen tissue was set on the sieve. Then pot soil was mixed thoroughly and 100g soil was taken from it on the tissue. Water was poured carefully in such a way so that the level could just touch and wet the soil at the beneath of the sieve keeping soil steady. Precautions were taken to avoid overflow. The system was kept untouched for three consecutive days (Figure 4). After 3 days the water from the bowl was taken to a beaker and left for a day. Excess water was discarded keeping 100 ml suspension. 5 ml of subsample was taken and put into a counting dish. Juveniles were counted under a compound microscope.

**Figure 4. Extraction of *Meloidogyne* sp. from soil by Bangladeshi plate method (Whitehead and Hemming, 1965) modifidly applied in the laboratory at the Department of Plant Pathology.**

### 3.15. Gall index

Root galls were indexed on a 0-10 scale (Bridge and Page, 1980)

| Scales | Specification |
|---|---|
| 0 | No gall |
| 1 | Few small gall, difficult to find |
| 2 | Small gall only, clearly visible, main root clean |
| 3 | Some larger galls visible, main root clean |
| 4 | Larger galls predominant but main root clean |
| 5 | 50% of the roots infected, galling on some main roots, reduced root system |
| 6 | Galling on main roots |
| 7 | Majority of the main roots galled |
| 8 | All main roots including tap roots galled, few clean roots visible |
| 9 | All roots severely galled, plants usually dying. |
| 10 | All roots severely galled, no root system |

### 3.16. Host Susceptibility designation

Host susceptibility designation was determined according to (Salawu, 1978):

| **Scale** | **Number of gall** | **Specification** |
|---|---|---|
| 0 | No gall | Immune |
| 1 | 1-2 | Resistant |
| 2 | 3-10 | Moderately resistant |
| 3 | 11-30 | Susceptible |
| 4 | 31 and above | Highly susceptible |

### 3.17. Analysis of data

The data were statistically analyzed using analysis of variance to find out the variation of results from experimental treatments. Treatment means were compared by LSD. Data were analyzed according to Randomized Complete Block Design by MSTAT software.

# CHAPTER - IV

# RESULTS

# RESULTS

The aim of this experiment was a preliminary screening of thirteen brinjal cultivars against *Meloidogyne* spp. and also to examine the effect of these nematodes on the growth of the thirteen brinjal cultivars.

## 4.1. Screening of different brinjal cultivars/lines against *Meloidogyne* spp.

The thirteen Brinjal cultivars varied widely in their susceptibility to *Meloidogyne* spp. The primary objective of this study was to evaluate the response of thirteen Brinjal cultivars against *Meloidogyne* spp as a resistance source for nematode management.

## 4.2. Shoot length, fresh shoot weight and dry shoot weight of brinjal cultivars as influenced by inoculation of *Meloidogyne* spp.

Screening trial test was done in the net house and shoot lengths, fresh shoot weights and dry shoot weights were taken. Findings revealed that shoot length, fresh shoot weight and dry shoot weight varied significantly with brinjal cultivars.

BARI begun-7 showed the highest shoot length both in un-inoculated control condition (86.33 cm) which was closely followed by BARI Begun- 10 (68.33 cm), BARI Begun-4 (66.00 cm). In inoculated with *Meloidogyne* the highest shoot length was recorded in BARI begun-7

(74.20cm) which was statistically identical with the cultivar BARI Begun- 10 (66.80 cm).

The lowest shoot length was found form in un-inoculated control condition in Deshi (11.00 cm) which was statistically similar to Mollika (12.07 cm) and BARI begun-1 (13.17 cm). In inoculated with *Meloidogyne the* lowest shoot length was found in Khotkhotia (8.40cm) which was statistically similar to Mollika (8.50 cm), BARI begun-1 (9.90 cm) and Deshi (12.00 cm). (Table 1).

The highest fresh shoot weight was found in BARI begun-4 (146.80 g) in un-inoculated controlled condition which was closely followed by BARI begun-9 (111.40 g)but in inoculated condition with *Meloidogyne* the highest was in BARI begun-7 (118.30 g) which was statistically similar to BARI begun-10 (118.20 g) and BARI begun-9 (106.2 g).

The lowest fresh shoot weight was found in Deshi (1.67 g) which was closely followed by Khotkhotia (8.73 g), Mollika (9.93 g) and BARI begun- 1 (11.63 g) inun-inoculated controlled condition, but in inoculated condition with *Meloidogyne* the lowest fresh shoot weight was found in Deshi (2.30 g) which is statistically similar to Mollika (3.08 g). (Table 1).

The highest dry shoot weight was found in BARI begun-9 (28.00 g) in un-inoculated controlled condition which was statistically similar BARI begun-7 (27.27 g), BARI begun-4 (26.73 g). In highest dry shoot weight was recorded BARI begun-7 (30.76 g) in inoculated condition with *Moloidogyne* which was statistically similar to BARI begun-10 (27.92 g) and BARI begun-9 (26.98 g).

The lowest dry shoot weight was found in Deshi (0.33 g) in un-inoculated controlled condition which was followed by Mollika (2.23 g), Khotkhotia (2.98 g) and in inoculated condition with *Meloidogyne* the lowest was Deshi (0.60 g) which was statistically similar to Mollika (1.12 g), Khotkhotia (2.05 g) and Uttora (2.44 g). (Table 1).

**Table 1.Shoot length, fresh shoot weight and dry shoot weight of brinjal cultivars as influenced by inoculation of *Meloidogyne* spp.**

| Brinjal cultivars | Shoot length (cm) | | Shoot weight (g) | | | |
|---|---|---|---|---|---|---|
| | | | Fresh shoot weight (g) | | Dry shoot weight (g) | |
| | Control | Inoculated with *Meloidogyne* | Control | Inoculated with *Meloidogyne* | Control | Inoculated with *Meloidogyne* |
| BARI Begun-7 | 86.33 a | 74.20 a | 103.40 b | 118.30 a | 27.27 ab | 30.76 a |
| BARI Begun-9 | 61.67 b | 63.00 b | 111.40 b | 106.2 a | 28.00 a | 26.98 a |
| BARI Begun-10 | 68.33 b | 66.80 ab | 104.30 b | 118.20 a | 23.13 b | 27.92 a |
| BARI Begun-4 | 66.00 b | 64.60 b | 146.80 a | 78.90 b | 26.73 ab | 17.64 b |
| Tobla | 47.00 c | 48.40 c | 43.43 c | 40.08 c | 9.490 cd | 11.42 c |
| BARI Begun-5 | 43.67 c | 32.20 d | 20.47 de | 21.36 cde | 10.30 c | 10.44 c |
| Irri | 41.00 c | 35.20 d | 20.97 de | 19.36 cde | 7.83 cde | 9.34 c |
| Deshi | 11.00 f | 12.00 f | 1.67 e | 2.30 e | 0.33 g | 0.60 e |
| Mollika | 12.07 f | 8.500 f | 9.93 e | 3.08 e | 2.23 fg | 1.12 e |
| BARI Begun-1 | 13.17 f | 9.900 f | 11.63 e | 7.30 de | 3.40 efg | 2.39 de |
| Khotkhotia | 15.00 ef | 8.400 f | 8.73 e | 9.82 de | 2.98 fg | 2.05 e |
| Shingnath | 24.93 de | 21.90 e | 23.67 cde | 28.18 de | 5.77 def | 7.00 cd |
| Uttara | 35.33 cd | 28.30 de | 34.89 cd | 19.45 cde | 4.21 efg | 2.44 e |
| LSD (P≥0.1) | - | 7.487 | - | 20.29 | - | 4.452 |


(A)


(B)

**Plate 6. Photograph showing growth of shoots of BARI begun-7 in un-inoculated control condition (A) and inoculated condition (B)**


(A)


(B)

**Plate 7. Photograph showing growth of shoots of BARI begun-9 in un-inoculated control condition (A) and inoculated condition (B)**


(A)

(B)

**Plate 8. Photograph showing growth of shoots of BARI begun-10 in un-inoculated control condition (A) and inoculated condition (B)**


(A)

(B)

**Plate 9. Photograph showing growth of shoots of BARI begun-4 in un-inoculated control condition (A) and inoculated condition (B)**


(A)


(B)

**Plate 10. Photograph showing growth of shoots of Tobla in un-inoculated control condition (A) and inoculated condition (B)**


(A)


(B)

**Plate 11. Photograph showing growth of shoots of BARI begun-5 in un-inoculated control condition (A) and inoculated condition (B)**

.


(A)


(B)

**Plate 12. Photograph showing growth of shoots of Irri in un-inoculated control condition (A) and inoculated condition (B)**

(A)

(B)

**Plate 13. Photograph showing growth of shoots of Deshi in un-inoculated control condition (A) and inoculated condition (B)**


(A)


(B)

**Plate 14. Photograph showing growth of shoots of Mollika in un-inoculated control condition (A) and inoculated condition (B)**


(A)


(B)

**Plate 15. Photograph showing growth of shoots of BARI begun-1 in un-inoculated control condition (A) and inoculated condition (B)**


(A)


(B)

**Plate 16. Photograph showing growth of shoots of Khotkhotia in un-inoculated control condition (A) and inoculated condition (B)**


(A)


(B)

**Plate 17. Photograph showing growth of shoots of Shingnath in un-inoculated control condition (A) and inoculated condition (B)**


(A)


(B)

**Plate 18. Photograph showing growth of shoots of Uttora in un-inoculated control condition (A) and inoculated condition (B)**

## 4.3. Root length, root weight and leaf number/plant of brinjal cultivars as influenced by inoculation of *Meloidogyne* spp.

Examining with root length, root weight and leaf number showed that the longest root was found in BARI begun-10 (35.00 cm) in un-inoculated controlled condition which was statistically similar to BARI begun-7

(32.67 cm), BARI begun-4 (32.00 cm) and Irri (30.67 cm). In case of inoculated condition BARI begun-7 (27.60 cm) and BARI begun-10 (27.60 cm) showed the longest root length.

While Deshi showed the shortest root length both in un-inoculated controlled condition and inoculated condition (9.63 cm and 7.60 cm) (Table 2).

The highest root weight was found in un-inoculated controlled condition was BARI begun-4 (28.73 cm) which was followed by and BARI begun-7 (22.53 cm).

In inoculated condition BARI begun-7 (30.66 cm) showed highest root weight which was statistically similar to BARI begun-4 (26.64 cm), BARI begun-9 (25.64 cm) and BARI begun-10 (24.64 cm).

The lowest root weight was recorded in un-inoculated controlled condition was Mollika (1.13 g) preceded by Khotkhotia (1.76 g), Deshi (1.83 g) and BARI begun-1 (2.77 g) which were statistically similar and in inoculated conditions the lowest was recorded in Khotkhotia (1.90 g) preceded by Deshi (2.12 g), BARI begun-1 (2.86 g), Mollika (2.88 g) and Uttora (3.52 g) (Table 2).

In case of leaf number the highest leaf number was seen in BARI begun-4 (23.67) in un-inoculated controlled condition and in inoculated condition BARI begun-7 (20.20) and BARI begun-9 (20.20) showed the highest leaf number. Deshi (3.00 and 4.80) showed the lowest numbers of leaves both in un-inoculated controlled condition and inoculated condition. (Table 2).

**Table 2. Root length, root weight and leaf number/plant of brinjal cultivars as influenced by inoculation of *Meloidogyne* spp.**

| Brinjal cultivars | Root length (cm) | | Root weight (g) | | Number of leaf | |
|---|---|---|---|---|---|---|
| | Control | Inoculated with *Meloidogyne* | Control | Inoculated with *Meloidogyne* | Control | Inoculated with *Meloidogyne* |
| BARI Begun-7 | 32.67 a | 27.60 a | 22.53 b | 30.66 a | 15.67 c | 20.20 a |
| BARI Begun-9 | 12.33 cd | 14.20 cde | 17.13 c | 25.64 a | 19.33 b | 20.20 a |
| BARI Begun-10 | 35.00 a | 27.60 a | 18.93 bc | 24.62 a | 8.33 de | 15.40 b |
| BARI Begun-4 | 32.00 a | 18.20 bc | 28.73 a | 26.64 a | 23.67 a | 15.00 b |
| Tobla | 20.67 b | 17.40 bcd | 8.40 de | 13.34 b | 11.67 d | 8.60 c |
| BARI Begun-5 | 16.33 bc | 17.40 bcd | 8.50 de | 10.20 bc | 9.00 de | 8.60 c |
| Irri | 30.67 a | 22.20 b | 10.57 d | 10.18 bc | 6.67 e | 5.40 cd |
| Deshi | 9.63 d | 7.600 f | 1.83 f | 2.12 d | 3.00 f | 4.80 d |
| Mollika | 12.33 cd | 13.94 cde | 1.13 f | 2.88 d | 8.67 de | 5.00 cd |
| BARI Begun-1 | 13.33 cd | 14.20 cde | 2.77 f | 2.86 d | 8.33 de | 6.80 cd |
| Khotkhotia | 12.27 cd | 10.56 ef | 1.76 f | 1.90 d | 8.33 de | 5.60 cd |
| Shingnath | 15.90 bc | 11.60 def | 4.33 ef | 5.56 cd | 10.33 de | 7.40 cd |
| Uttora | 11.17 cd | 12.06 def | 4.03 ef | 3.52 d | 10.00 de | 8.00 cd |
| LSD (P≥0.1) | - | 5.313 | - | 5.541 | - | 3.188 |

(A)

(B)

**Plate 19. Photograph showing growth of roots of BARI begun-7 in un-inoculated control condition (A) and inoculated condition (B)**

(A)

(B)

**Plate 20. Photograph showing growth of roots of BARI begun-9 in un-inoculated control condition (A) and inoculated condition (B)**


(A)


(B)

**Plate 21. Photograph showing growth of roots of BARI begun-10 in un-inoculated control condition (A) and inoculated condition (B)**

(A)

(B)

**Plate 22. Photograph showing growth of roots of BARI begun-4 in un-inoculated control condition (A) and inoculated condition (B)**


(A)


(B)

**Plate 23. Photograph showing growth of roots of Tobla in un-inoculated control condition (A) and inoculated condition (B)**

(A)

(B)

**Plate 24. Photograph showing growth of roots of BARI begun-5 in un-inoculated control condition (A) and inoculated condition (B)**

(A)

(B)

**Plate 25. Photograph showing growth of roots of Irri in un-inoculated control condition (A) and inoculated condition (B)**

(A)

(B)

**Plate 26. Photograph showing growth of roots of Deshi in un-inoculated control condition (A) and inoculated condition (B)**

(A)

(B)

**Plate 27. Photograph showing growth of roots of Mollika in un-inoculated control condition (A) and inoculated condition (B)**

(A)

(B)

**Plate 28. Photograph showing growth of roots of BARI begun-1 in un-inoculated control condition (A) and inoculated condition (B)**

(A)

(B)

**Plate 29. Photograph showing growth of roots of Khotkhotia in un-inoculated control condition (A) and inoculated condition (B)**

(A)

(B)

**Plate 30. Photograph showing growth of roots of Shingnath in un-inoculated control condition (A) and inoculated condition (B)**

(A)

(B)

**Plate 31. Photograph showing growth of roots of Uttora in un-inoculated control condition (A) and inoculated condition (B)**

## 4.4. Influence of brinjal cultivars on number of egg masses/root, number of eggs/egg mass, total number of eggs/root system, and total number of nematode population/pot of *Meloidogyne* spp.

In case of number of egg masses per root system (Fig 4), the highest was found in BARI begun-10 (438.40) which was statistically similar with BARI begun-4 (417.60) and the lowest was recorded in Uttara (80.80). (Table 3).

Number of eggs/egg mass (Fig 5) was found to be the highest in Shingnath (503.20) which was closely followed by BARI begun-10 (293.80) and the lowest number of eggs/egg mass was recorded in Mollika (180.10) preceded by BARI begun-1 (186.10) which were statistically identical with Uttara (180.60) .

The highest total number of eggs/root system was found to be in BARI begun-5 ($66.81\times10^2$) which was followed by Irri ($51.22\times10^2$) and the lowest was in BARI begun-10 ($12.94\times10^2$).

Number of J2/ 4 kg soil was the highest in BARI begun-7 (28.00) followed by Irri (26.80) and BARI begun-1 (25.60), and the lowest was in Uttora (12.80). All were statistically similar to each other.

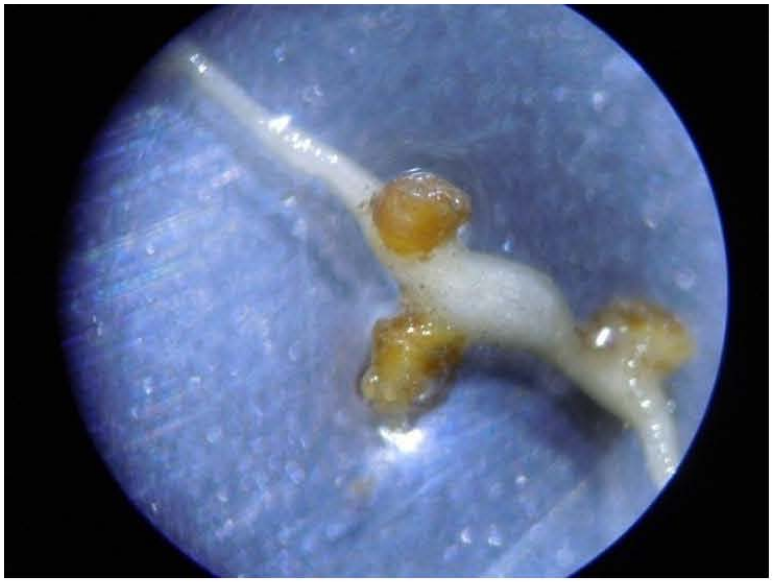


**Figure 5. Photograph showing egg masses on root system of *Meloidogyne* sp.**

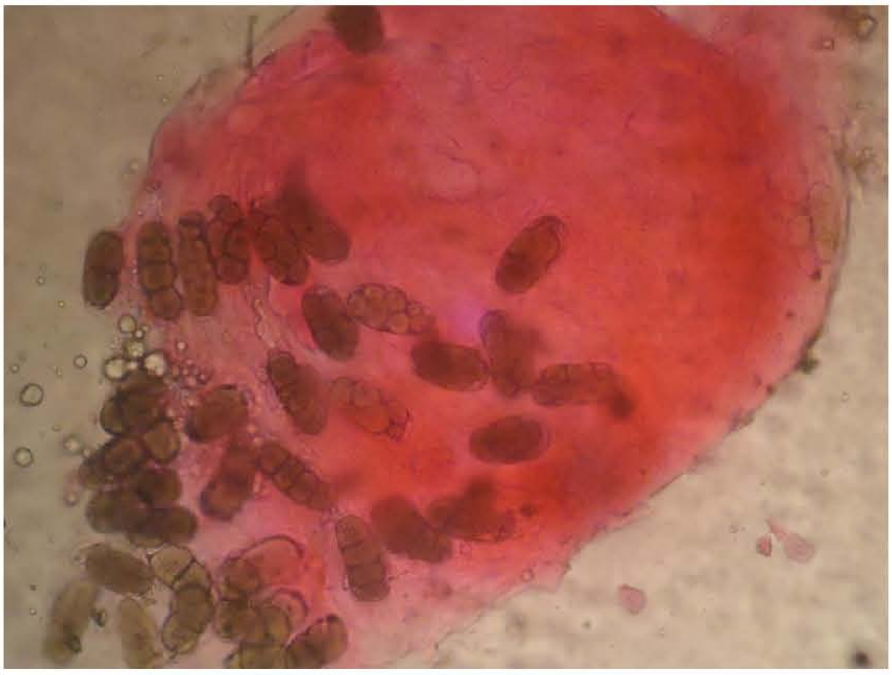


**Figure 6. Photograph showing eggs per root system of *Meloidogyne* sp. under compound microscope (10x).**

The highest total number of nematode population/pot was found to be in BARI begun-4 ($31.64\times10^3$) which was followed BARI begun-4 ($29.53\times10^3$) and the lowest in Uttora ($13.10\times10^3$) (Table 3).

**Table 3. Influnce of brinjal cultivars on number of egg mass/root, number of egg/egg mass, total number of egg/root system, and total number of nematode population/pot of *Meloidogyne* spp.**

| Brinjal cultivars | Number of egg mass/root | Number of egg/egg mass | Total number of egg/root system($\times10^2$) | Number of J2/4 kg soil | Total number of population / pot ($\times10^3$) |
|---|---|---|---|---|---|
| BARI Begun-7 | 296.80 bcd | 269.90 b | 34.12 bc | 28.00 a | 25.37 abc |
| BARI Begun-9 | 214.20 cdef | 202.60 cd | 44.03 ab | 22.00 a | 26.40 abc |
| BARI Begun-10 | 438.40 a | 293.80 b | 12.94 c | 14.00 a | 26.94 abc |
| BARI Begun-4 | 417.60 ab | 292.50 b | 27.43 bc | 20.80 a | 31.64 a |
| Tobla | 347.80 abc | 260.80 bc | 49.89 ab | 18.40 a | 16.74 de |
| BARI Begun-5 | 306.80 abcd | 273.40 b | 66.81 a | 18.40 a | 15.99 de |
| Irri | 272.40 cde | 289.10 b | 51.22 ab | 26.80 a | 16.48 de |
| Deshi | 183.60 def | 245.20 bcd | 45.40 ab | 14.00 a | 20.51 cd |
| Mollika | 202.00 def | 180.10 d | 36.67 bc | 23.60 a | 27.26 abc |
| BARI Begun-1 | 208.60 cdef | 186.10 d | 39.35 bc | 25.60 a | 29.53 ab |
| Khotkhotia | 161.00 def | 238.60 bcd | 35.88 bc | 18.00 a | 20.67 cd |
| Shingnath | 143.20 ef | 503.20 a | 31.65 bc | 17.20 a | 24.37 bc |
| Uttora | 80.80 f | 180.80 d | 30.17 bc | 12.80 a | 13.10 e |
| LSD | 125.7 | 87.03 | 24.02 | 14 | 6.215 |

## 4.5. Gall formation in root system of different brinjal cultivars as influenced by inculation of *Meloidogyne* spp.

While studying the effect of gall formation in root system the highest number of galls was found in Deshi (9.00) and the lowest was recorded in Uttora (2.60). (Figure 5.)

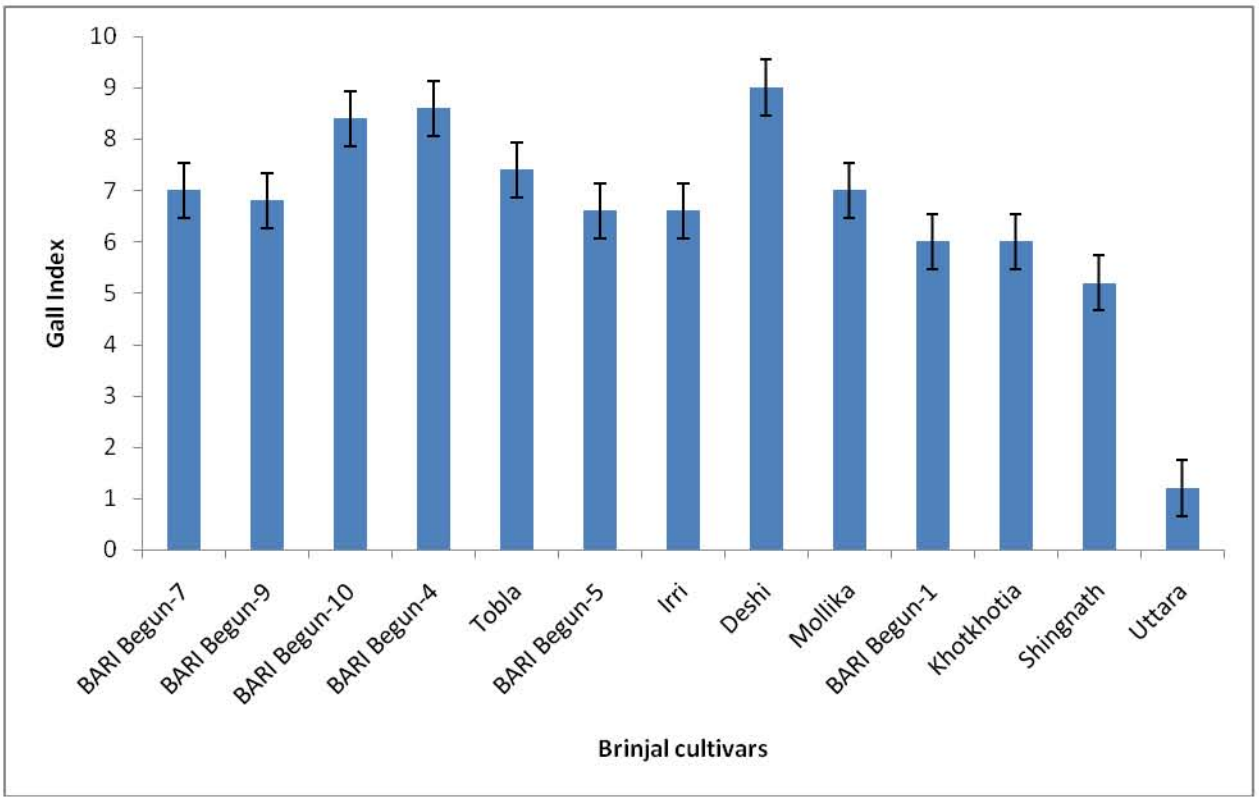



**Figure 6. Gall formation in root system of different brinjal cultivars as influenced by inculation of *Meloidogyne* spp. Vartical bars represent mean ± Standard Error (SE).**

### 4.6. Reproduction factor of *Meloidogyne* spp as influenced by different brinjal cultivars.

The highest number of reproduction factor was found in BARI begun-4 (31.64) and the lowest was recorded in Uttora (8.24). (Figure 6)

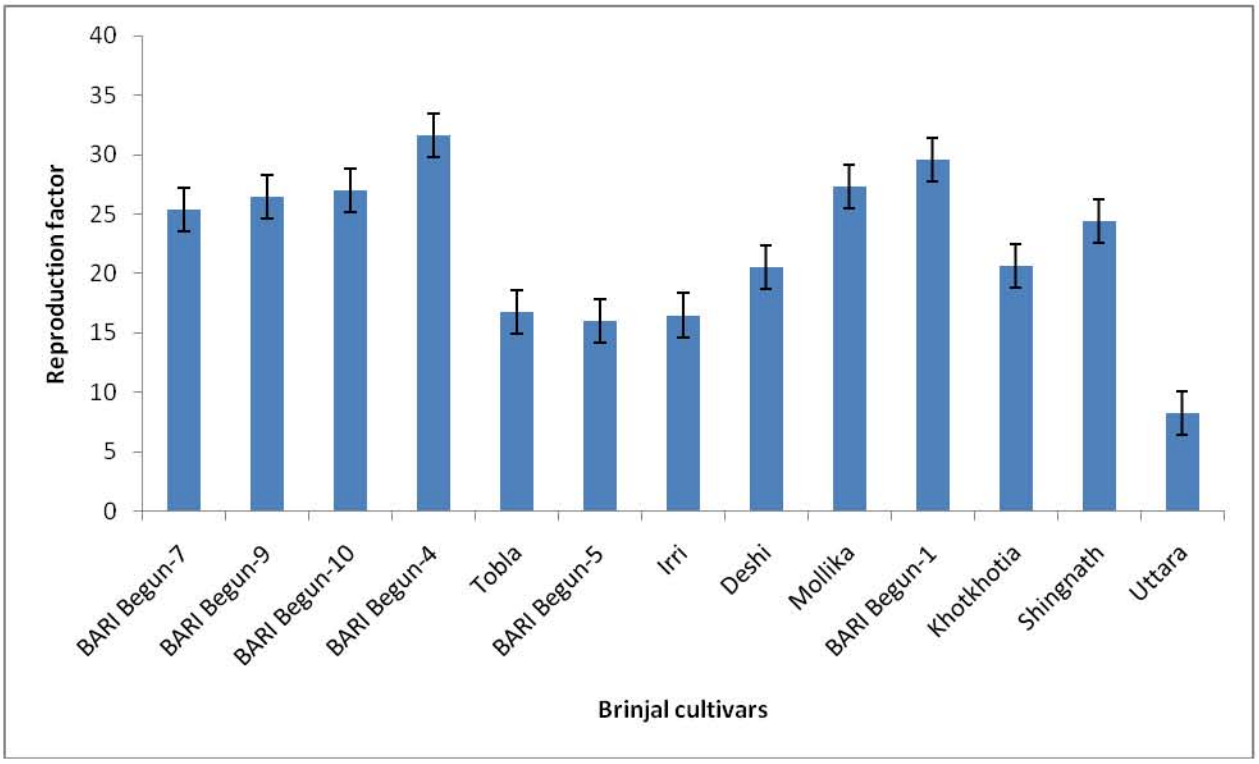



**Figure 7. Reproduction factor of *Meloidogyne* spp as influenced by different brinjal cultivars. Vartical bars represent mean ± Standard Error (SE).**

## 4.7. Reaction of galls formation per root system of different brinjal cultivars as influenced by inculation of *Meloidogyne* spp.

Host susceptibility designation was determined according to salawu (1986). The greatest number of galls in root system was in Deshi (45.59) followed by BARI Begun-4 (43.3) and the lowest in Uttora (9.81) preceded by Singnath (26.93) (Table 4.).

**Table 4. Reaction of thirteen brinjal (*Solanum melongena*) cultivars to *Meloidogyne* spp.**

| Brinjal cultivars | No of galls/root system** | Grading of variety | Varietal Reaction*** |
|---|---|---|---|
| BARI Begun-7 | 35.33 cd | 4 | HS |
| BARI Begun-9 | 34.12 d | 4 | HS |
| BARI Begun-10 | 42.54 abc | 4 | HS |
| BARI Begun-4 | 43.3 ab | 4 | HS |
| Tobla | 37.26 c | 4 | HS |
| BARI Begun-5 | 33.8 de | 4 | HS |
| Irri | 33.13 de | 4 | HS |
| Deshi | 45.59 a | 4 | HS |
| Mollika | 35.74 cd | 4 | HS |
| BARI Begun-1 | 30.28 fg | 3 | S |
| Khotkhotia | 30.61 f | 3 | S |
| Shingnath | 26.93 fg | 3 | S |
| Uttora | 9.81 h | 2 | MR |

** Averages of 5 replications

*** Grading of varieties wasbased on gall index values,

where 0 = No gall = Immune,

1= 1-2 galls = Resistant,

2= 3-10 galls = Moderately resistant,

3= 11-30 galls = susceptible,

4= 31 galls and above = Highly susceptible, Salawu (1978).

# CHAPTER - V

# DISCUSSION

# DISCUSSION

Among the plant parasitic nematodes occurring throughout the world root knot nematodes are the most prevalent and important group found more frequently and in greater numbers in warm and hot regions. Root knot nematodes deprive nutrients from infected plants and reduce the market value of fruit by affecting the quality. At seedling stage, heavy losses result in complete destruction of the crop (Khan, 2009). These nematodes injure the roots and provide entry for the other pathogens.

In the experiment, thirteen brinjal genotypes were tested against the *Meloidogyne* spp. The screening of brinjal cultivars revealed that none of the brinjal cultivar was immune to root knot nematode, though the incidence varied from cultivar to cultivar. All the 13 brinjal cultivars viz. BARI begun-7, BARI begun-9, BARI begun-10, BARI begun-4, Tobla, BARI begun-5, Irri, Deshi, Mollika, BARI begun-1, Khotkhotia, Shingnath, Uttora (Table 1) all the genotypes showed variability in their response to *Meloidogyne* spp. infestation.

Shoot length was significantly increased in brinjal variety BARI Begun-7 followed by BARI Begun-10 and BARI Begun-4 and that was decreased in brinjal variety Khotkhotia as compared to un-inoculated brinjal variety

Mollika, Deshi and BARI Begun-1. Shoot weight was significantly reduced in brinjal variety Deshi followed by Mollika inoculated with *Meloidogyne* spp as compared to BARI Begun-7, BARI Begun-9, BARI Begun-10 than that of un-inoculated brinjal variety BARI Begun-4,BARI Begun-9 respectively.

Maximum reduction in shoot growth was also recorded in inoculated brinjal varieties than that of un-inoculated brinjal varieties. The growth of tomato seedlings was significantly reduced when artificially inoculated with *Meloidogyne* spp. which was reported by Maqbool and Ghazala (1986) . Darban (1994) observed that growth of tomato variety Roma was decreased when inoculated with different inoculum levels of *M. incognita.* Screening of five tomato and three eggplant varieties under different inoculum levels of M.*inocgnita* was done by Dabaj *et al.* (1996) and recorded their effect on growth.

Root knot nematode, *Meloidogyne* spp significantly reduced root length in tomato variety Deshi both un-inoculated controlled condition as compared to BARI begun-7 and BARI begun-10 in inoculated condition and un-inoculated brinjal variety BARI begun-10, BARI begun-4, BARI begun-7. Root weight was decreased in Khotkhotia in inoculated condition which was followed by Deshi, BARI begun-1 (2.86 g), Mollika

and Uttora than that of un-inoculated brinjal variety BARI begun-7 and BARI begun-4.

According to Setty and Wheeler (1968) the increase in root weight in affected plants might be due to the larger amount of growth substances, more tryptophan and other amino acids than un-inoculated plants and had inverse impact on shoot length. There was inverse relationship between shoot and root weight at all level of *Meloidogyne* spp but these findings did not agree with the hypothesis of Wareing (1970) that root and shoot are mutually dependent upon each other for exchanging nutrients, carbohydrates, growth substances and are physiologically in equilibrium and any reduction in root growth limit the shoot growth or vice versa. So these observations suggested that root weight was not a good parameter for the assessment of plant growth.

The progressive decrease in plant growth and nematode multiplication with increasing of inoculum on different crops had also been reported (Salem and Eissa, 1981; Paruthi and Gupta, 1985; Pankaj and Siyanand, 1990; Satyend and Goswami, 2000; Youssef and El-Nagdi, 2004; Khan *et al.*, 2004; Haseeb *et al.*, 2005; Nadary *et al.*, 2006). This research concludes that nematode attack disturb the coordination between roots and shoot leading to poor plant growth. Trudgill (1992) reported that

# CHAPTER – VI

# CONCLUSION

# CONCLUSION

The thirteen brinjal varieties showed variability in their response to *Meloidogyne* spp infestation. Deshi, BARI Begun-4, BARI Begun-10, Tobla, BARI Begun-7, BARI Begun-9, BARI Begun-5, Irri were highly susceptible while Khotkhotia, BARI begun-1 and Shingnath were categorized as susceptible. Uttora was proved to be moderately resistant.

Deshi, BARI Begun-4, BARI Begun-10, Tobla, BARI Begun-7, BARI Begun-9, BARI Begun-5, Irri were highly susceptible because of their plant

Response of all the plants were different to root knot nematodes. Plant height, fresh shoot weight and dry shoot weight was the maximum in control plants than in inoculated plants with exceptions in case of BARI begun-9, Tobla and Deshi. BARI begun-9, Tobla and Deshi which showed high susceptibility with excessive growth.

Controlled plants were significantly different from the inoculated plants. Root length, fresh root weight and leaf number was the maximum in healthy plants and it was higher than inoculated plants. Root length was found to be maximum in BARI begun-7 and BARI begun-10 Fresh root

weight was maximum in inoculated BARI begun-10 and BARI begun-4 cultivars.

Maximum number of egg/root system was recorded in BARI begun-5 but maximum population of nematode was recorded in BARI begun-4. Maximum reproduction factor was also recorded in BARI begun-4. Maximum galls were recorded in Deshi and Minimum in Uttora.

The cultivars BARI Begun-7, BARI Begun-9, BARI Begun-10, BARI Begun-4, Tobla, BARI Begun-5, Irri, Deshi, Mollika were screened as highly susceptible varieties. Number of egg mass/root were 296.80. 214.20, 438.40, 417.60, 347.80, 306.80, 272.40, 183.60, 202.00. Number of egg/egg mass were 269.90, 202.60, 293.80, 292.50, 260.80, 273.40, 289.10, 245.20, 180.10. Total no of egg masses/root system ($x10^2$) were 34.12, 44.03, 12.94, 27.43, 49.89, 66.81, 51.22, 45.40, 36.67. No of j2/4kg soil were 28.00, 22.0, 14.00, 20.80, 18.40, 18.40, 26.80, 14.00, 23.60. Total no of nematode population/pot ($x10^3$) were 25.37, 26.40, 26.94, 31.64, 16.74, 15.99, 16.48, 20.51, 27.26. RF were 25.37, 26.40, 26.94, 31.64, 16.74, 15.97, 16.48, 20.51, 27.26. According to Bridge and Page; (1980), (0-10) gall index scale showed 7, 6.80, 8.40, 8.60, 7.40, 6.60, 6.60, 9.00, 7.00 and accoding to Salawu (1978), host susceptibility designation scale were 35.33, 34.12, 42.54, 43.3, 37.26, 33.8, 33.13,

45.59, 35.74 whose grading was 4 there varietal reaction show they are highly susceptible.

The cultivars BARI Begun-1, Khotkhotia, Shingnath were screened as susceptible where number of egg mass/root were 208.60, 161.00, 143.20, number of egg/egg mass were 186.10, 238.60, 503.20, total no of egg mass/root system ($x10^2$) were 39.35, 35.88, 31.65, no of j2/4kg soil were 25.60, 18.00, 17.20, total no of population/pot ($x10^3$) were 29.53, 20.67, 24.37 and RF were 29.53, 20.67, 24.37. According to Bridge and Page (1980), (0-10) gall index scale showed 6.00, 6.00, 5.20 and according to Salawu (1978), host susceptibility designation scale were 30.28, 30.61, 26.93 whose grading was 3 there varietal reaction show they are susceptible.

Uttora was moderately resistant where number of egg masses/root was 80.80, number of eggs/egg mass was 180.80, total no of egg masses/root system ($x10^2$) was 30.17, No of j2/4kg soil was 12.80, total no of nematode population/pot ($x10^3$) was 13.10 and RF was 13.10. According to Bridge and Page (1980), (0-10) gall index scale showed 1.20. According to Salawu (1978), host susceptibility designation scale was 9.81 whose grading was 2, it was found that uttara showed moderately resistant.

There is need for more research in screening program including more cultivars and lines of brinjals to be tested against several races of *Meloidogene* spp.

plant generates more roots to overcome the limitations due to nematode damage Such appears to be the main mechanism of damage by *Meloidogyne* spp whose effect was further increased by reductions in root efficiency resulted in a decrease in root-shoot ratio.

The number of root-galls was significantly increased in brinjal variety Deshi followed by BARI Begun-10,BARI Begun-4 as compared to Uttora that was decreased in brinjal variety Shingnath .

The greater number of egg masses per root system was obtained in brinjal variety BARI Begun-5 followed by Irri and minimum was recorded in BARI Begun-10 respectively.

Maximum number of eggs per egg mass was found in brinjal variety Shingnath followed by BARI Begun-10 as compared to Mollika, BARI Begun-1 and Uttora.

Greater number of females, galls and eggs per plant was found in susceptible cultivars inoculated with *Meloidogyne* spp as compared to moderately resistant cultivars (Roberts and May, 1986). Although *Meloidogyne* spp multiplied on all brinjal cultivars but there was variability in pathogenicity, which might be due to presence of nematode resistant gene (Hadisoeganda and Sasser, 1982; Roberts and Thomson,

1986). These genes made the plant less attractive for attacking nematodes.

Different plant responses to nematode infection were observed. Compatible and incompatible reactions may be due to the presence of resistant genes which are activated as a result of nematode invasion andsome visible reactions can be observed in the plant cells (Williamson, 1999; Davis *et al.*, 2000; Williamson and Kumar, 2006)

Number of J2/ 4 kg soil was significantly increased in variety BARI Begun-7 followed by Irri, BARI Begun-1 and that were decreased in Uttora.

Rao *et al.* (1998) found post-penetration of second stage larvae of *M. incognita* in tomato hybrid FM-2 and Pusa Puby before and after transplanting.

BARI begun-9, Tobla and Deshi was found to be tolerant to the attack of root-knot nematodes. It gave maximum increase in plant height and minimum increase in fresh and dry shoot weight with gall index of (4). The results on the occurrence of *Meloidogyne* spp in brinjal are inconformity with screening trial of sunflower (Krishnappa & Setty, 1983; Montasser *et al.*, 1985; Zazzerini & Tosi, 1997).

# CHAPTER – VII

# REFERENCE

# REFERENCES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Deshi, BARI Begun-4, BARI Begun-10, Tobla, BARI Begun-7, BARI Begun-9, BARI Begun-5, Irri were highly susceptible with gall index of (4). Khotkhotia, BARI begun-1 and Shingnath were categorized as susceptible on the basis of gall index (3) and Uttora was categorized as Moderately resistant on the basis of gall index (2) (Salawu, 1978).

Naresh Nayak and J. L. Sharma (2013) observed that among 16 brinjal variety Pusa purple long was recorded highly susceptible having root gall index 5.0. Six verities which showed resistant and moderately resistant to root-knot nematode having root gall index between 0.1 to 2.0 under pot trail. Vijay and Annamalai showed resistant. It was also observed that the remaining 10 verities were moderately susceptible, susceptible and highly susceptible to root-knot nematode with root gall index between 2.1 to 5.0. Pusa Purple long was reported as slightly susceptible against *M.incognita (*Haider *et al.*, 2001), Jain *et al.* (1983) discussed as slightly resistant to *M. javanica*. Syamala was found moderately resistant by Harinath Naidu *et al.* (2006). Vijay and Annamalai was reported as resistant by many workers (Haider *et al.*, 2001; Nandwana *et al.*,1980) and also but discussed as susceptible by many workers (Sharma *et al.*, 1988; Parvatha Reddy *et al.*, 1986).

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In the moderately resistant plants nematodes fail to produce enough functional feeding sites in the host after invasion due to hypersensitive responses which leads in failure to develop subsequently as reproducing females (Williamson and Kumar, 2006). Two types of mechanisms for root knot nematode resistance in plants have been reported including pre-infection resistance against root knot nematodes which is due to presence of toxic or antagonistic chemicals in root tissue which prevent the entry of root knot nematodes in roots (Haynes and Jones, 1976; Bendezu and Starr, 2003) while in pots-infection resistance, nematodes penetrate roots but fail to develop. It is often associated with an early hypersensitive reaction due to the death of the cell in root tissue around the nematode. This mechanism prevents the formation of a developed feeding site leading to resistance. Resistant brinjal plants show typical hypersensitive reaction upon a virulent root knot nematode infection (Dropkin, 1969; Williamson, 1999).

It was reported that resistant cultivars have gene of resistance in their gene pool that confers resistance to *Meloidogyne* spp (Boiteux and Charechar, 1996). In the resistant roots, catalase activity is decreased as a result of root knot nematodes attack. There is a possible role of alkaloids or phenolics that may inhibit the synthesis of these enzymes and act as an elicitor of resistance in plant attacked by *Meloidogyne* species.

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Development and reproduction of *Meloidogyne* spp was reflected by resistance and susceptibility of the plant (Cook and Evans, 1987; Khan *et al.*, 2004) as our results indicated on cultivar Uttora reproductions factor ($P_i/P_f$) of nematodes was lowered as compared to other cultivars. This study contributed information on the reaction of various brinjal cultivars to *Meloidogyne* spp.

The gall index and root weight was not directly related to egg masses. But final population was directly proportional to rate of reproduction (Pathan *et al.*, 2004; Sharma *et al.*, 2005). It was observed that an increase in the inoculum level resulted in a progressive increase in the host infection as indicated by number of galls, gall index and egg masses per root system. The statistical analysis indicated that there was a direct relationship between root gall and production of egg masses. Gall index and total plant fresh weight showed inverse relationship. The nematode multiplication was the maximum at initial inoculum level and then started decreasing at highest inoculums levels. It might be due to the intra specific competition among nematodes for food (Seinhorst, 1961).

The result of the pathogenecity study revealed that *Meloidogyne* spp suppressed the brinjal growth with the increase in inoculum level and corresponding reduction in the growth. Damage caused by *Meloidogyne*

spp increased by increasing inoculum level so there was increasing plant damage between increasing population and plant growth. In such situations, degree of damage depends upon the susceptibility and tolerance of the host plant (Seinhorst, 1965).