

BIOLOGICAL CONTROL OF ROOT-KNOT
(*Meloidogyne javanica*) OF TOMATO



A Thesis

By

MD. HARUN-OR-RASHID

Student No.0805025

Semester: Summer, March-August, 2009

Session: 2008-2009

MASTER OF SCIENCE (M.S)
IN
PLANT PATHOLOGY

Department of Plant Pathology
Hajee Mohammad Danesh Science and Technology University
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Submitted to the

Department of Plant Pathology

Hajee Mohammad Danesh Science and Technology University, Dinajpur

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE (M.S)

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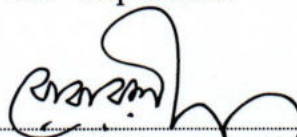
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June, 2009

**DEDICATED TO
MY BELOVED PARENTS
AND ESTEEMED TEACHERS**

ABSTRACT

Of two sets of pot experiment, first one was conducted with standard leaf extract of Bashak (*Adhatoda vasica*), Satodrone (*Leucas aspera*), Bermuda grass (*Cynodon dactylon*) and Mustard (*Brassica napus*) oil-cake extract to evaluate their efficacy against root-knot (*Meloidogyne javanica*) disease of tomato after 7 days of transplantation. Standard extract of Bashak showed the best performance followed by Mustard oil-cake, Satodrone and Bermuda grass as evident with better plant growth characters like length of shoot and root, fresh weight of shoot and root with higher yield and reduction of galls compared to the control treatment. In the second experiment, Soil drenching as an application method of BAU-Biofungicide, gave superior response followed by the other application methods of BAU-Biofungicide like Seed treatment, Root dipping and Foliar spray on plant growth parameters and yield with reduced galling than control treatment. Negative correlations between galling incidence and shoot and root length as well as with yield indicated the strong positive effect of the treatments as envisaged with the suppression of the nematode activity enhancing growth and yield of tomato.

ACKNOWLEDGEMENT

The author greatly expresses his deepest sense of gratitude to the Almighty Allah for His ever-ending blessing for the successful accomplishment of this research work.

The author wishes his profound sense of appreciation, heartiest gratitude and indebtedness to his Supervisor, S.M. Emdadul Hassan, Associate Professor, Department of Plant Pathology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur for his help, keen interest, continuous encouragement, scholastic supervision and constructive suggestions during the entire period of the research work and in preparing the thesis.

The author also avails the opportunity to express gratitude and profound indebtedness to his research Co-Supervisor SK. Md. Mobarak Hossain, Associate Professor, Department of Plant Pathology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur for his valuable suggestions, encouragement, valuable instruction, taking the photographs of the experiment and carefully reviewing the manuscript.

The author expresses his deepest and sincere gratitude to Professor Dr. Md. Mamunur Rashid, Chairman, Department of Plant Pathology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur for time to time encouragement and sincere co-operation during the course of study.

Sincere indebtedness and appreciation are rendered to A. T. M. Shafiqul Islam, Associate Professor, Md. Mohidul Hasan, Assistant Professor, Md. Shamim Hassan, Lecturer, Department of Plant Pathology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur for valuable advice and inspiration during this study.

Thanks are also extended to all staff members, Department of Plant Pathology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur for their co-operation during the study period.

The author extremely thankful to Riya, Sumon, Omi, Mizu, Rabiul, Raju and others who helped to collect the data and carefully typing the manuscript with utmost patience and sincerity.

Finally, the author is highly indebted to his parents, brothers, sisters and relatives for their everlasting blessings, inspiration, co-operation, encouragement, sacrifice and dedicated efforts to educate him up to this level.

“THE AUTHOR”

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CHAPTER 1

INTRODUCTION

Tomato (*Lycopersicon esculentum* L.) belongs to the family Solanaceae and is one of the most important, popular and nutritious vegetable crops in Bangladesh. It is widely grown not only in Bangladesh but also in every part of the world. At present, tomato ranks third next to potato and sweet potato in terms of world vegetable production (Anon., 2002) and tops the list of canned vegetables (Choudhury, 1979). The present leading tomato producing countries of the world are China, USA, India, Egypt, Turkey, Iran, Italy, Mexico, Brazil and Indonesia (Anon., 2002). It occupies an area of 485.38 lakh acres of land and its annual production is 1430.58 lakh metric tons (Anon., 2008).

Large quantities of tomato are used to produce soup, juice, puree, paste and powder. Tomato is also popular because it supplies vitamin C and adds variety of colors and flavors to the foods. Green tomatoes are also used for pickles and preservation. It has many other uses; such as tomato seed contains 24% oil and this is extracted from the pulp and residues in canning industry. The semi drying oil is used as salad oil and in the manufacture of margarine.

Tomato is also rich in medicinal value. The pulp and juice are digestible mild aperients, promoters of gastric secretion and blood purifier. It is also considered to be intestinal antiseptic. It is said to be useful in canker of the mouth, sore mouth etc. Dried tomato juice retains vitamin C. It is one of the richest vegetables which keeps our stomach and intestine in good condition.

In spite of increasing demand of tomato, its production in our country is not satisfactory. Because its production is often threatened by various diseases. Among these, nematode diseases play a significant role in reducing its productivity. Root-knot nematodes have the greatest impact on crop productivity especially when they attack the roots of seedlings immediately after seed germination (Ploeg, 2001). In Bangladesh, tomato is affected at

various stages of growth by many diseases including root-knot caused by *Meloidogyne* spp. (Timm and Ameen, 1960; Chowdhury, 1976; Ahmad, 1977 and Mian, 1986). Nematodes are the most important disease causing agents in the tropical and sub-tropical regions of the world (Anon., 1978 and Hooker, 1981). *Meloidogyne javanica* and *Meloidogyne incognita* are important nematode species in this sub-continent because of their wider host range (Kishore, 1969). Consequently, Bangladesh is a suitable bed for the predominantly occurring nematode species. A preliminary survey conducted by Page (1979) showed that 36 different crops and vegetables were found to be attacked by root-knot disease. As a result enormous crop loss is incurred every year in Bangladesh.

Farmers use chemicals to control nemic disease. Indiscriminate use of chemicals for controlling disease of crop plants has great impact on environmental pollution, health hazards etc. (Alam, 1987). Moreover, huge amount of foreign currency is needed to purchase plant-protecting chemicals. Biological agents are now being used in many developed countries as an alternate means of using chemicals for combating the diseases with the aim of increasing food production.

Biological control of pathogens offers environmentally safe, durable and cost effective alternatives to chemicals (Papavizas and Lumsden, 1980), which differs fundamentally from conventional chemical control. Bio-control with beneficial microbes manipulates the environment around a crop plant to favour the organism that contributes to plant health and vigour. In such control action, living microorganism such as bacteria, viruses and fungi act as antagonists, parasites or predators (Kwok *et al.* 1987). *Trichoderma* spp. are known as antagonists to plant pathogenic nematodes (Goswami and Satyendra-Singh, 2004; Devi *et al.*, 2002; Sharon *et al.*, 2001; Manuzca, 2001; Devila *et al.*, 1999 and Tverdyukev *et al.*, 1994). These fungi have been found to stimulate the growth of the plant.

The nematode disease of crops can be controlled by using Carbofuran (Furadan) as reported by Reddy (1988); Nayak *et al.* (1990); Zahid *et al.* (1992); Barman and Das (1998); Sharma (1999); Janathan and Rajendran (2000) and Vyas and Patel (2001). Furadan is systemic in action. Systemic chemicals are more effective against endoparasitic pathogens (Homeyer, 1973). Now-a-days, Furadan (Carbofuran) is commonly available in Bangladesh which is now being locally formulated. These chemicals can control nematodes for their systematic action. However, these are very expensive for marginal farmers of our country. It is also a difficult task for farmers to use them with specified doses in the fields. Besides, it is well known that environmental pollution occurs due to the use of chemicals in the field. For these reasons, use of chemicals is being discouraged all over the world.

Nematode population can be controlled applying various plant extract, Many plant extracts have been reported to have antifungal, antibacterial and anti-nematode properties (Irshad *et al.* 1982 and Stephan *et al.* 1989.)

Plant extracts like Bashak, Pineapple, Satodrone, Neem, Bermuda grass, Dholkalmi, Marigold, Mustard oil cake, rhizome of Ginger etc. are the source of organic soil amendment and they are effective in controlling root-knot and other plant parasitic nematodes and they also improve the soil condition as well as fertility of the soil. Mustard oil-cake contains phenolic and other toxic compounds which are found to be lethal to many nematode pathogens including root-knot nematode *Meloidogyne* spp. (Mian and Rodriguez-Kabana, 1982). Leaf of Bashak (*Adhatoda vasica*), Satodrone (*Leucas aspera*) and Bermuda grass (*Cynodon dactylon*) are easily available throughout the country. Moreover, these are cheap and eco-friendly in nature and are also found to be toxic. Extracts of Bashak, Satodrone and Bermuda grass are easy to prepare and can easily be handled. A few approaches have been taken to initiate the control of root-knot nematode in northern region of Bangladesh through biological means.

With this view in mind, the present research work has been undertaken to see the effect of leaf extracts of Bashak, Satodrone, Bermuda grass and Mustard oil-cake extract on the incidence of root-knot of tomato caused by *Meloidogyne javanica* with the following objectives:

1. To know the effect of plant extracts and BAU-Biofungicide against root-knot (*Meloidogyne javanica*) of tomato.
2. To detect the superior plant extract on the different growth stage of tomato plant inoculated with *Meloidogyne javanica*.
3. To find out the suitable method of application of plant extracts and BAU-Biofungicide for the control of root-knot of tomato.

CHAPTER 2

REVIEW OF LITERATURE

Biological control of nematode diseases of plant with leaves extracts and BAU-Biofungicide is relatively new approach of disease control by biological means. Many workers in this field have been using this practice especially to control the root-knot disease caused by *Meloidogyne* spp. Some important literature of many research activities relevant to the present study are reviewed in this chapter.

Hameed (1970) reported that addition of decomposed leaves of *Chrysanthemum coronarium*, *Melia azadirachta*, *Tagetes patula*, *Datura fustuosa* and *Nerium indicum* as farmyard manure and pressmud to the soil reduced the incidence of *Meloidogyne* spp. in tomato and increased plant growth.

Ducusion and Davide (1972) reported that pot trials in the Philippines showed that inoculation of tomato (rainy season var. 2029) with *Meloidogyne incognita* eggmasses at planting gave 85.3% yield loss and 39.9% if inoculated at the flowering stage. Field trials of tomato growth after the addition of sawdust or chicken manure or planting with *Tagetes erecta*, showed reduced galling on plants treated with chicken manure yield increases of 43% and 68%, respectively. The other treatments had no effect. However, tomato root-galling was greatly reduced when *Tagetes erecta* was grown for several months before the tomatoes were planted. The effect of *Tagetes* and tomato root extracts at various dilutions on the hatching of *Meloidogyne incognita* is described.

Johnson (1974) observed that a substance was extracted from mature, dried oat straw and leaves and stem segments of flax which was toxic to eggs and larvae of *Meloidogyne incognita* in inoculation experiments on tomato seedlings. No galls were produced on tomato roots inoculated with either eggs or larvae treated with alcohol extracts of 20 g samples of un-decomposed oat straw or

flax. Material toxic to eggs was extracted with alcohol and ether from oat straw and flax-amended soil also contained material toxic to larvae. No toxins were demonstrated in water extracts of amended soil. A substance toxic to larvae, but less so to eggs, was extracted with ether from soil without an organic amendment. These results indicate the toxic may be rapidly degraded or strongly absorbed in soil since smaller quantities were extracted from soil amended with similar amounts of oat straw or flax.

Pillai *et al.* (1975) reported that extracts of turmeric (*Curcuma longa*) possess nematicidal properties as shown by the fact that they kill the second stage larvae of *M. javanica*. Boiled extracts are more effective in killing the larvae than the un-boiled extracts.

Egunjobi and Afolami (1976) noted that four water extracts of the leaves of *Azadirachta indica* in concentrations of 1.5, 1.0 and 0.5 kg fresh leaves/3 litre water were found in in-vitro test to be directly toxic to *Pratylenchus brachyurus*. Boiled extracts become toxic within the first 4 hours of exposure, there being a linear relationship between concentrations at 24 hours exposure. The juice of *Citrus aurantifolia* fruits seemed to reduce the toxicity of the neem extracts under semi-field conditions.

Zaiyd (1977) reported that *Meloidogyne javanica* gall number was reduced and plant top weight was increased by addition of mustard cake, groundnut cake, linseed cake and castor cake to okra plants in pot trials. Neem leaves (*Azadirachta indica*) also gave some control.

Trivedi *et al.* (1978) practised with oil-cakes of *Arachis hypogaea*, *Sesamum indicum*, *Brassica campestris* or *Eruca sativa* at 2.5, 5, 7.5 or 10% (of the soil) to soil in pots infested with *Meloidogyne incognita* 15 days before seedling of *Capsicum annum* were transplanted into the pot. Water soluble and insoluble extracts of the oil-cakes were also treated for nematicidal properties. Oil-cakes at 2.5 and 5% were more effective in enhancing growth and reducing galling

than the water soluble or insoluble extracts with the exception of *S. indicum* oil-cakes. Oil cake of *A. hypogaea* was the most effective.

Kanaujia and Mishra (1978) studied the effect of leaf extract of *Calotropis procera* and *Datura metal* on phyllosphere mycoflora of *Pennisetum typhoides*. Different concentrations of the leaf extracts of the two plants were used in the study. The leaf extracts of *D. metal* proved to be more effective than that of *C. procera*. The spore germination of certain fungal species was considerably lowered in the extract of the two plant species.

Mian *et al.* (1982) studied the nematicidal properties of 15 materials of plant origin in glasshouse experiment with soil infested with *Meloidogyne arenaria*. Spent coffee grinds, *Crotalaria*, kudzu (*Pueraria lobata*) or ramie (*Boehmeria nivea*) hays applied at 1% (w/w) were the most effective in reducing root galling caused by nematode on *Cucurbita pepo*. The nematicidal efficacy of all the amendments was directly correlated with nitrogen content and inversely related to their C/N ratios. Amendments with materials having C/N ratios in the range of 15-20 were the most effective when all the amendments were applied at 100%; application of materials with narrower C/N ratios resulted in severe phytotoxicity.

Mian and Rodriguez-Kabana (1982) studied the effect of soil amendments with oil-cakes and chicken litter for control of *Meloidogyne arenaria* in greenhouse experiments with squash (*Cucurbita pepo* L.). The amendments reduced root galling caused by nematode and stimulated plant growth. The degree of nematode control was dependent on the amount of material added, oil-cake amendment of 0.4% or more practically eliminated root galling.

Haseeb *et al.* (1982) reported that leaf extract of *Mentha viridis*, *Emblica officinalis* and *Carrisa carandas* showed significant activity against *Meloidogyne incognita* larvae.

Mahmood *et al.* (1982) reported that the effect of different concentrations of leaf and seed extract of various indigenous medicinal plants known to possess anthelmintic properties has been studied on the mortality of *Rotylenchulus reniformis* and *Meloidogyne incognita*. All the plant extracts tested showed high degree of mortality of *R. reniformis* and *M. incognita*. The mortality rate decreased with the increase of dilution of the extracts. Similarly, the mortality rate increased with the increase in the exposure period. Extracts of leaves of *Anagallis arvensis* and the seed of *Linum usitatissimum* and *Sida cordifolia* proved to be highly toxic.

Prot and Kornprobst (1983) observed that pre-treated with crude seed extracts of *Azadirachta indica*, *Hannoa undulata* and *H. klaineana* inhibited the penetration of *Meloidogyne javanica* juveniles into tomato roots.

Hussain *et al.* (1984) found that the root-dip treatment of *Solanum melongena* seedling with or marigold leaf extract, mustard cake considerably reduced the development of *Meloidogyne incognita* as compared to treatment with *Piperazine citrate*, chenopodium oil and groundnut cake. They also observed that treatments with 'half-standard' of *Artemisia maritima* were better for plant growth improvement, but for disease control, 'standard' concentration was more effective.

Sharma *et al.* (1985) used powders of 9 plants (leaf at 5.0, 7.5 and 10.0 g/kg soil) which were applied to *Cucumis melo* in pots for control of *Meloidogyne incognita*. Lowest population after 45 days was found in soil treated with *Tagetes* or *Xanthium* leaf powders, followed by *Verbesina* and *Artemisia*.

Prot and Kornprobst (1985) observed that soil amendment of crude powder of *Hannoa undulata* seeds fully inhibited the reproduction of *Meloidogyne javanica* on tomato roots.

Sartaj *et al.* (1985) reported that some of the plants of the family compositae are known to possess nematicidal properties. Extracts were prepared from different plant parts (root and stem, leaf and flower) of the tested plants *Gaillardia picta* and *Tithonia diversifolia* and then diluted in different concentrations as S, S/10 and S/100. These different concentrations were tested on the mortality of second-stage juveniles after 12, 24 and 48 hrs. Both test plant exhibited highly nematode toxicity.

Goswami and Vijaylakshmi (1986) observed that the number of galls per g of roots was reduced by 9 different plant extracts especially with *Euclipta alba*, *Shorea robusta* and *Datura metal*. They also observed that the shoot and root length and the shoot weight of tomato cv. Pusa ruby infected with *M. incognita* were increased by all the extracts especially with *Amaranthus* spp., *Calotropis gigantea*, *Datura metal* and *Euclipta alba*.

Mani *et al.* (1986) reported the effect of extracts of the following plant spp. (dried and powered), *Agemone maxicana*, *Azadirachta indica*, *Calotropis gigantea*, *Gleome viscosa*, *Datura stramonium*, *Eucalyptus globulus* and *Tagetes erecta* on the mortality of nematode. The standard leaf extract 'S' was prepared and from which 1 and 5% solutions were also prepared and applied on second stage juveniles of *Tylenchulus semipenetrans* in petridish. Juvenile mobility decreased as the concentration of extract and the exposure periods increased.

Nandal and Bhatti (1986) recorded that leaf extracts of *Calotropis procera*, *Datura stramonium*, *Ricinus communis* and *Xanthium strumarium* significantly reduced the gall formation in all *Solanum melongena* plants.

Sartaj *et al.* (1986) observed the effect of different concentrations of an extract of lemon grass (*Cymbopoga flexus*) on the mortality of some commonly occurring plant parasitic nematodes. The concentration of the extract was maintained according to the following method where standard extract was

prepared by 25 g of macerated grass leaves with 75 ml of distilled water and the other solutions S/10 and S/100 were also prepared. The toxicity was increased with the increase of the concentration of the extracts.

Alam (1987) observed that results from pot experiments showed that chopped plant leaves when incorporated into naturally infested soil, effectively suppressed population of plant parasitic nematodes and improved growth of tomato cv. Marglobe. This type of nematode control was considered economical, easy and pollution free.

Guzman and Saxena (1987) observed that derivatives from the neem tree (*Azadirachta indica*. A. Juss) namely neem oil, neem extract and neem cake showed high nematicidal activity against the root-knot nematode, *Meloidogyne incognita*, Chitwood in both laboratory and greenhouse tests. In vitro test showed a progressive significant increase in mortality of second stage larvae in the different neem treatments and they were observed to undergo protoplasmic vacuolation in contrast to motile, healthy larvae in the untreated control treatments. In pot experiment, inhibitory effects on production of galls in tomato plants were evident when applied with of 4 to 5 part of neem cake.

Rossner and Zebitz (1987) studied the influence of ground neem leaves and seed kernels (1% v/v) on the growth of tomatoes (var. Hellfrucht) and on the populations of *Pratylenchus penetrans* and *Meloidogyne arenaria* in pots in the greenhouse. The initial growth of tomatoes in soil treated with neem was retarded but subsequently and strikingly favoured compared with the untreated control. The size of plants, number of leaves and weight of shoots, roots and fruits increased. The number of root galls caused by *M. arenaria* was highest on plants growing in untreated soil (index 4.2) and lower in soil treated with ground neem leaves (index 3.1) and lowest in soil treated with ground neem seed kernels (index 2.5). There was a significant reduction in the number of *P. penetrans* extracted from the roots (control 2318 nematodes per g of roots; ground leaves, 453; and ground seed kernels, 536). In a field experiment in

which an additional treatment with extracted seed kernels was included, the result of the greenhouse experiment was confirmed in principle. The growth of tomato plant was obviously improved by neem products, but there was no significant difference in the number of some nematodes species in the soil. However, among treated and untreated soils the majority was extracted from the roots of plants in untreated soil. The experiment confirmed in principle that tomato growth can be improved by neem products. In addition, the reduction of certain nematode species may contribute to the good plant growth in neem treated soil.

Lee (1987) reported that *Melia azadirach* leaf and seed extracts inhibited hatching of root-knot nematode (*Meloidogyne incognita*) eggs (associated with a delay in embryonic development) reduced nematode motility and killed the larvae. Four months old *Paulownia taiwaniana* saplings treated with extracts had significantly greater height and fewer root-knots suggesting that inter planting *P. taiwaniana* with *Melia azadirach* might help to control the nematode.

Malik *et al.* (1987) reported the nematicidal activities of essential oils of leaves, purified essential oil and extracts of roots or stem of *X. strumarium* which were compared. All fractions studied caused acceptable larval mortality in *Tylenchulus semipenetrans*. Mortality of *Heterodera cajani* was consistently higher in the presence of essential oil and roots or stem extracts than that of *Meloidogyne javanica*.

Scramin *et al.* (1987) reported about extracts of 14 plants species in laboratory for their nematicidal and namatode inhibiting properties. The extracts were obtained by fractioning with different organic solvents and were then bioassayed with *M. incognita*. The results revealed potential activity in some extracts of the following plants *Tagetes minuta*, *T. patula*, *Alomia fastigita* and *Ageratum conyzoides*.

Siddiqui and Alam (1987) reported that seeds of tomato, aubergines and okra were coated with water soluble extracts of *Azadirachta indica* and *Melia azadirach* and the resultant seedlings were inoculated with different doses of *M. incognita* and *R. reniformis*. Both seed treatments significantly reduced galling and *R. reniformis* population build up. The effect was more pronounced in plants grown from seed coated with fruit extract of leaves, flowers, bark or with gum.

Arya and Saxena (1988) found that with the standard extracts of leaves of *L. camara* there was no hatching of *Meloidogyne incognita* larvae. Hatching increased as dilution of extracts increased when soils naturally infested with *M. incognita* were amended with 5, 10, 15 or 20 g of *L. camara* leaves, nematode populations decreased, the reduction being directly proportional to the amount of leaves incorporated.

Chhabra *et al.* (1988) reported that six plant species were tested for this leaf extracts toxicity to J₂ of *M. incognita*. Leaf extracts of *Ricinus communis* was the most toxic followed by *Leucaena leucocephala*, *Populus deltoides*, *Azadirachta indica*, *Lantana camara* and *Eucalyptus hybrida*, respectively. Fresh extracts were more toxic than boiled ones except in *E. hybrida*.

Mohanty and Das (1988) reported that the leaf extract (5 g fresh leaves/15 ml water) of *E. indica* at 1:1 and 1:5 dilutions proved highly toxic to *M. incognita* and *T. mashhoodi*. Within 6 hours of exposure, nematodes were immobilized and failed to revive even after transfer to distilled water. *M. incognita* was more sensitive than *T. mashhoodi*.

Pathak *et al.* (1988) studied the effect of fresh, chopped, dried, ground leaves and plant parts and compost of water hyacinth (*Eichhornia crassipes*) and dried and ground neem (*Azadirachta indica*) leaves at 30 q/ha were added to pots of aubergines infested with *M. incognita*. Dried and ground neem leaves gave maximum yield. All treatments significantly decreased number of galls and eggmasses.

Zaki and Bhatti (1989) observed the nematicidal effects of leaves of three species (*Calotropis procera*, *Ricinus communis* and *Azadirachta indica*) and of their paired combinations on the growth of tomato (height and weight). In all treated plants, there was reduction in the nematode population.

Ahmad *et al.* (1990 a) worked with the extracts of *Ananas comosus*, *Punica granatum*, *Nerium indicum* (oleander), *Calotropis procera*, *Ricinus communis*, *Plumeria rubra* and *Ipomoea fistulosa* in a pot experiment for their effect on *M. javanica*. Extracts of *P. rubra* (leaf and bark) and *I. fistulosa* were found more toxic to juvenile mortality followed by *N. indicum* (leaf and fruit). Standard concentrations of all extracts caused 100% mortality within 12h.

Ahmad *et al.* (1990 b) reported that standard plant extract (S) of shatamuli (*Asparagus officinalis*) suppressed the activity of *Meloidogyne javanica* with lower galling incidence and corresponding higher growth characters of brinjal.

Alam (1990) reported that neem (*Azadirachta indica*) had good properties in controlling plant parasitic nematodes.

Darekar *et al.* (1990) tested the effect of neem (*Azadirachta indica*), karanj cake (*Pongamia glabra*), mahua (*Madhuca indica*) and castor (*Ricinus communis*) oil seed cakes in a field experiment in furrows and for control of *M. incognita* on tomato. All treatments at 400 kg/ha reduced *M. incognita* populations and gall index, with neem and karanj cake being the most effective.

Saifullah and Gui (1990) tested the following soil amendments for the control of *Meloidogyne* spp. on tomatoes in a pot experiment. Cotton oil-cake (*Gossypium hirsutum*), castor oil-cake (*Ricinus communis*), mustard oil-cake (*Brassica campestris*), linseed oil-cake (*Linum angustifolium*) or sesame oil-cake (*Sesamum indicum*) all at 13 g/ pot and, wheat straw or sawdust both at 8g/ pot, all amendments greatly suppressed nematode populations with mustard and linseed oil-cake having the best effect.

Ahmad *et al.* (1991) noted that leaf extracts of *Azadirachta indica*, *Melia azadirach*, *Datura alba* and *Ricinus communis* were highly toxic to *M. incognita*. *A. indica* gave maximum (100%) inhibition of egg hatching and larval mortality followed by *M. azadirach*, *Datura alba* and *R. communis*. Inhibition of egg hatch and larval mortality were significantly affected by the concentration of the leaf extracts and the exposure time.

Ahmad and Karim (1991) reported that standard (S) and half-standard (S/2) solutions of dholkalmi (*Ipomoea fistulosa*) suppressed the activity of *M. javanica* with significant lower galling incidence and corresponding higher significant shoot and root length, fresh weight of shoot and root of brinjal.

Ganai *et al.* (1992) investigated in vitro the effect of leaf extracts of neem *Azadirachta indica*, *Mentha piperita* and *Parthenium hysterophorus* on *Ditylenchus myceliophagus*. All extracts caused significant nematode mortality with the maximum occurring with *A. indica*.

Kashem *et al.* (1994) found that the bulb extract of garlic was highly toxic to juvenile mortality of *M. javanica* responsible for rot-knot of brinjal. Garlic extract even at S/100 concentration suppressed the nematode activities as evidenced by no incidence of galling and corresponding significant growth of plants. Garlic extract appeared to be highly nematocidal both in the laboratory and glasshouse test.

Mukhtar *et al.* (1994) observed that leaf extracts of *Azadirachta indica*, *Melia azadirach*, *Datura alba* (*Datura metal*) and *Ricinus communis* were applied to tomato plants inoculated with *M. incognita* in a pot trial. All extracts except *R. communis* enhanced plant growth and reduced disease severity with *A. indica* extract being the most effective.

Islam (1995) tested the bittergourd (*Momordica charantia*) fruit extract and powder prepared from seeds against the root-knot (*Meloidogyne javanica*) disease of cucumber (*Cucumis sativus*) in glasshouse. Of four different

treatments including control, treatment T₂ with concentration 'S' (standard) of bittergourd extract suppressed the activity of *Meloidogyne javanica* with significantly lowest galling incidence of cucumber. Significantly highest length of shoot and root and fresh weight of shoot and root with corresponding lowest galling incidence were recorded with this concentration in all the tests. Comparatively, better and identical growth responses of plant with corresponding lower galling incidence were observed with concentration S/2 of bittergourd fruit extract and its seed powder.

Byomakesh *et al.* (1998) conducted an experiment to evaluate the comparative efficacy of 4 neem products (neem bitter 0.5 %, repolin 1 %, welgrow 1 % and neem seed extracts 2.5 %) against *M. incognita* infecting tomato. Application by seed treatments, bare root dipping of seedling and foliar spraying proved that all the neem products were effective in reducing the root-knot disease incidence and increasing growth of plants.

El-Moity *et al.* (1998) found that three antagonists, *Trichoderma harzianum*, *Gliocladium virens* and *Bacillus* sp. (B15) isolated from Egyptian soil, were used alone or in combinations to control the root-knot nematode, *M. incognita* on tomato plants. The treatments were applied once (one week before transplanting) or twice (before planting and 20 days after planting) at 20 ml/pot (20 cm in diameter; containing 2.5 kg steam-sterilized soil, i.e. loam, peat and sand at 4:3:2). Each pot was inoculated with suspension of egg masses containing 3000 eggs by making 3 holes at different depths (2-3 cm) around the roots. The most effective in controlling the root-knot nematode was *Bacillus* sp. (B.15), whereas the least effective was *T. harzianum*. No synergistic effect was obtained when different combinations from the antagonists were applied. Application of the antagonist to infested soil, twice was always more effective compared with single treatment. Application of *Bacillus* sp. twice was more effective than chemical treatment. Treatment with the antagonists separately or in combination decreased the number of egg masses, eggs per plant and 2nd stage larvae in soil and increased the fresh weight of either the root or shoot system.

Spiegel and Chet (1998) said that the implementation of *Trichoderma* in integrated pest management (IPM) can be achieved using a soil treatment which combines reduced amounts of biocides/fungicides and the *Trichoderma* preparation. Bio-control activity can be increased by combining 2 (or more) types of bio-control agents. Moreover, the construction of a genetically modified *Trichoderma* can lead to the improvement of certain traits which are absent or not highly expressed in the native micro-organism isolated from its natural inhabitat. Different *T.harzianum* and *T. lingorum* (*T. viride*) isolates were tested for their nematicidal activity against the root-knot nematode, *Meloidogyne javanica*. In short-term experiments, improved growth of nematode infested plants and decreased in the root-galling index and the number of eggs per gram of root were achieved when nematode-infested soils were pre-exposed to the *T. harzianum* preparations.

Reddy *et al.* (1997) evaluated the fungal bio-control agent, *Trichoderma harzianum*, the endomycorrhiza, *Glomus fasciculatum* and neem-cake (*Azadirachta indica*) either singly or in combination (at half the doses) for the management of *Meloidogyne incognita* infecting tomato under nursery and main field conditions. In the nursery, integration of neem-cake with *G. fasciculatum* gave maximum increase in plant growth parameters and the least root-knot index. Root colonization was maximum when neem-cake was integrated with *G. fasciculatum*, while egg parasitization was highest when neem-cake was integrated with *T. harzianum*. Under field condition, planting of tomato seedlings (raised in nursery beds treated with neem-cake + *G. fasciculatum*) in pots incorporated with *T. harzianum* grown on sorghum seeds at 0.5 g per plant was effective in increasing tomato fruit yield and for the management of root-knot nematodes.

Devila *et al.* (1999) stated that species of *Trichoderma* especially *T. harzianum* which had great potential as nematode bio-control agent since most of them had been found to be associated with eggs, larvae and females of *Meloidogyne* spp.

Sankaranarayanan *et al.* (1999) conducted a pot culture experiment to find out the nematicidal effect of the antagonistic fungi *Trichoderma harzianum* (3 isolates), *T. viride* (2 isolates), *Gliocladium virens* and *G. deliquescens* against *Meloidogyne incognita* on sunflower. The maximum plant height (78.87cm) was recorded in *T. harzianum*.

Siddiqui *et al.* (1999) stated that root dip treatment with *P. aeruginosa* with or without *Trichoderma harzianum*, *T. koningii* and *T. hamatum* significantly controlled infection of roots by *Fusarium solani*, *Rhizoctonia solani* and *Meloidogyne javanica* on *C. annum*. Combined use of *T. harzianum* with *P. aeruginosa* caused the greatest reduction in gall formation by *M. javanica*. Infection of *M. phaseolina* and *R. solani* was comparatively greater in *M. javanica* infested soil than in non-infested soil whereas *F. solani* infection was greater in non-infested soil. *P. aeruginosa* mixed with *Trichoderma* spp., also significantly increased plant growth.

Yang-Xiu Jung *et al.* (2000) reported that *Trichoderma* spp. showed significant efficiency in controlling *Meloidogyne* sp. and promoting the growth of tomato. In laboratory tests, the bio control efficiency of the fungi was 82.6%, while in field tests, it was 55.3% compared to the control plant, the height of treated tomato plants increased by 5.7cm.

Hemlata-Pant *et al.* (2000) conducted a pot study to assess the efficacy of *Trichoderma harzianum*, *Paecilomyces lilacinus* and *Aspergillus niger* against *Meloidogyne incognita* in chickpea genotype Type-3. Crop growth was best with *P. lilacinus* followed by *T. harzianum*, *A. niger* and a combination of all 3 bio-control agents. Maximum reduction of root-knot nematode was recorded with *P. lilacinus* followed by a combination of all bio-control agents, *T. harzianum* and *A. niger*.

Mohammad and Akhtar (2000) reported that the symptoms of root-gall caused by *M. incognita* were significantly reduced by the bare-root-dip treatment of

tomato seedling in a neem based commercial product and in an aqueous extract of neem seeds. Treatments with all concentrations at various periods of dipping time reduced root-knot development. It is also investigated that improvement in plant weight and height were correlated to reduction in nematode infestation.

Hafeez *et al.* (2000) studied that comparison of chemical and biological control treatments against *Meloidogyne incognita* was conducted on the basis of the number of galls formed on roots per tomato plant. *Paecilomyces lilacinus* and *Trichoderma harzianum* amended with organic substrate resulted in the minimum number of galls per plant which was 70.61 % less as compared with the control. The minimum reduction in galls was with Teneki which was 67.15 % less than the control.

In greenhouse experiments, Sharon *et al.* (2001) observed that root galling was reduced and top fresh weight was increased in nematode infected tomatoes following soil pre-treatment with *Trichoderma* peat bran preparations. It is suggested that improved proteolytic activity of the antagonist may be important for the biological control of the nematode.

Manuzca (2001) observed that plants inoculated with *Trichoderma*, *Verticillium*, *Paecilomyces* and *Gliocladium* had greater development of leaves and roots than plants inoculated with nematodes. *Trichoderma* resulted in 75% reduction in the number of galls and also reduced the nematode populations.

Siddiqui and Alam (2001) conducted an experiment to evaluate the nematicidal effects of fresh floral parts and decomposed flowers decomposed fruits (seeds) leaves and bark of neem (*Azadirachta indica*). Three week old seedlings of tomato were inoculated with 5000 freshly hatched L₂ juveniles of *M. incognita*. Root-knot development on tomato was significantly inhibited by all treatments and the growth of tomato also significantly improved by all treatments. It is also observed that decomposed materials were more effective than fresh floral parts in controlling nematodes and increasing plant growth.

Faruk *et al.* (2002) stated that a pot experiment and a field experiment were conducted to test the efficacy of soil amendment with different isolates of *T. harzianum*, mustard oil-cake and poultry refuse against the root-knot disease (*Meloidogyne incognita* and *Meloidogyne javanica*) of tomato. All treatments reduced severity of root-knot and increased plant growth and fruit yield over the control.

Devi *et al.* (2002) stated that *T. viride* and *T. harzianum* were mixed separately with soil at 1 g/kg soil. Three- to four-week-old tomato seedlings were transplanted into pots containing the *Trichoderma*-treated soil at 4 seedlings per pot. *M. incognita* nematode suspension (20 ml, containing approximately 500 juveniles isolated from pawpaw roots) was poured into the pots at 7 days after transplanting. Plant growth and nematode population were evaluated 90 days after nematode inoculation. Treatment with *Trichoderma* improved plant height, shoot weight, and root length and weight and reduced nematode population. The variation among treatments was not significant.

Devi and Hassan (2002) studied the effects of *T. viride* and organic manures (farmyard and poultry manures) on *M. incognita* and soybean cv. J-335 in Allahabad, Uttar Pradesh, India during the Kharif season of 2000. Soybean seeds were treated with *T. viride* at 50g/kg seeds and they found that all treatments improved plant growth (measured in terms of shoot height and of branches, leaves, and nodules) and reduced nematode galls formation.

Ansari *et al.* (2002) stated that the root-knot nematode, *Meloidogyne javanica* is an important parasite of field crops in the tropics. To develop eco friendly management options for this nematode, culture filtrates of *Pseudomonas striata* (strain 303), *Aspergillus awamori*, *Trichoderma harzianum* OPT NAB and *T. viride* were screened for their effects on egg-hatch in laboratory experiments. Results suggested that culture filtrates of *P. striata* strain 303 were the most effective in reducing egg hatch of *M. javanica* by upto 95% compared with controls, whereas culture filtrates from *A. awamori*, *T. harzianum* and *T. viride* reduced egg hatch by 13 to 69%.

Hemlata *et al.* (2002) conducted a study to determine the effect of using *T. harzianum* and neem-cake alone and in combination to manage *M. incognita* in chickpea cv. Type-3. Twenty clay pots were washed and filled with sterilized soil containing the mixture of neem-cake at 10q/ha. Ten days after sowing, plants were inoculated with *M. incognita* and *T. harzianum* at 1000 J₂ and 5000 spores per pot, respectively. The organic amendment and *T. harzianum* increased the chickpea growth over the control. Reduction of root-knot nematode was maximum with neem-cake + *T. harzianum* followed by neem-cake and *T. harzianum* alone.

Gopal-Pandey *et al.* (2003) observed that the gall development and final nematode population of *M. incognita* decreased with the increasing level of *T. viride* under pot and field condition. Maximum soil population was decreased with increasing level of *T. viride* and maximum root nodules and minimum root-knot nematode were observed in 4000 spores of *T. viride*.

Hossain (2003) observed that neem oil as seed treatment had better response on plant growth in reducing galls and nematode development. Seed treatment with neem fruit extract gave better response followed by neem bark extract in promoting plant growth and suppressing development of the nematode. Neem leaf extract as seed treatment was found to be less effective due to lower plant growth characters with higher numbers of galls and juvenile populations.

Hassan *et al.* (2004) conducted an experiment that the solutions of oil-cakes of mustard, til and soybean were used for controlling root-knot of potato, where solution of mustard oil-cake showed the best performance followed by til oil-cake. Mustard oil-cake was found best in increasing shoot length and root length with the reduction of galling by *Meloidogyne javanica* in potato variety, Pakhri lalita. Negative correlations between galling incidence and shoot length as well as root length indicated the positive effect of the treatments.

Hassan *et al.* (2005 a) found the efficacy of four indigenous plant extracts against the root-knot of okra. Marigold extract was found to be more lethal to the juvenile in the mortality test of *Meloidogyne javanica* compared to the dholkalmi, turmeric and thunkuni extract. Better plant growth with corresponding lower number of gall were recorded with extracts of marigold used.

Sultana *et al.* (2006) conducted an experiment to study the efficacy of BINA-Biofertilizer and BAU-Biofungicide against root-knot (*Meloidogyne incognita*) of soybean along with nematicide Curaterr. They found that BINA-Biofertilizer and BAU-Biofungicide gave better result in plant growth characters and yield of pods and seeds with reduced galling and nematode development.

CHAPTER 3

MATERIALS AND METHODS

3.1. Experimental site

Two Experiments were conducted both in the laboratory and the nethouse, Department of Plant Pathology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur. The duration of the experiment ranged from the 08th December, 2008 to the 09th April, 2009. The experiment was conducted in the laboratory to prepare Bashak (*Adhatoda vasica*), Satodrone (*Leucas aspera*), Bermuda grass (*Cynodon dactylon*) leaf extracts, Mustard (*Brassica napus*) oil cake extract and BAU-Biofungicide solution.

The first and the second experiments in pots were placed in the nethouse, Department of Plant Pathology, HSTU, Dinajpur. The first experiment was conducted to evaluate the effect of different plant leaf extracts of Bashak, Satodrone, Bermuda grass leaf extracts and Mustard oil cake extract following the methods Root dipping, Soil drenching and Foliar spray for each extract. The second experiment was conducted to detect the superior application method among Seed treatment, Root dipping, Soil drenching and Foliar spray with BAU-Biofungicide at different growth stages of tomato plant inoculated with *Meloidogyne javanica*.

3.2. Pot experiment

3.2.1. Preparation of pot soil and potting

At first sandy loam soil, sand and well decomposed cowdung were taken at the ratio of 2:1:1 and mixed uniformly. Sandy loam soil was collected from the field of HSTU campus, sand was collected from the riverside of the Purnavoba and well decomposed cowdung from the dairy farm of HSTU. Then the mixed soil was sterilized with formaldehyde solution at the rate of 30 ml formalin dissolved in 1000 ml water for per cubic feet soil. The formalin treated soil was

covered by brown paper for 72 hours without disturbance. After 72 hours, the brown paper was removed and the sterilized soil was exposed to air-drying for 48 hours in order to remove excess vapour of formalin. Earthen pot (30 cm diameter) was provided with a small broken piece of earthen pot at the bottom and filled with 5 kg sterilized and dried soil.

3.2.2. Collection and surface sterilization of tomato seeds

Apparently, mature, healthy and disease free seeds of tomato cv. Roton were collected from the local market. Before sowing these seeds in the seed bed surface sterilization of these seeds was done with low concentration of mercuric chloride solution (0.001%) for 1 minute and subsequently washing was done with water for thrice.

3.2.3. Collection of BAU-Biofungicide

BAU-Biofungicide was collected from Disease resistance Laboratory of Prof. Dr. Ismail Hossain, Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh.

3.2.4. Seed treatment with BAU-Biofungicide

A petridish was taken and was surface sterilized with methylated spirit before placing seeds for treating with BAU-Biofungicide @ 1:40 w/w (BAU-Biofungicide:seed) following the method of Hossain (2003) by moistening the seeds with rice froth. The seeds were thoroughly mixed with the BAU-Biofungicides by shaking petridish. The coated seeds were placed in a cool and dry place under shade for drying and the seeds were sown in the seed bed in the afternoon on the 8th December, 2008.

3.2.5. Sowing of seeds on the seedbed

One third amount of surface sterilized seeds of tomato were sown in separate seed bed with sterilized soil and the rest seeds were sown in the another seed

bed with sterilized soil after treating the seeds with BAU-Biofungicide for 30 minutes.

3.2.6. Preparation of plant leaf extracts (S)

Leaves of Bashak (*Adhatoda vasica*), Satodrone (*Leucas aspera*), Bermuda grass (*Cynodon dactylon*) were collected from the HSTU campus. The twenty gram of Bashak, Satodrone and Bermuda grass leaves were macerated in an electric blender and soaked separately in 100 ml distilled water in several conical flask and was kept for 24 hours. After 24 hours they were filtered. These filtrates were treated as standard (S) leaf extracts and prepared as T₁, T₃ and T₄ for first experiment, respectively.

3.2.7. Preparation of Mustard oil cake extract (S)

Mustard oil cake was collected from the local market. At first twenty gram of Mustard oil cake (MOC) was taken in a bucket and mixed with required amount of water until it came to a melting condition. After that it was filtered, treated as standard (S) and was prepared as T₂ for first experiment.

3.2.8. Transplantation and aftercare of the seedling

At first, healthy and uniform sized seedling of 30 days age were uprooted from the seedbed. Roots of seedlings are dipped in several treatments for 30 minutes and then placed singly in the sterilized pot soil. Special care was taken in uprooting the seedlings so that the seedlings can receive minimum injury. Before uprooting the seedlings, the seedbed was moistened sufficiently for easy lifting of the seedling. Transplantation was done in the afternoon at 08th January, 2009. Every tomato seedling was watered uniformly for the establishment of the roots to the soil along with its vigorous growth and development. The seedlings were watered twice, every morning and afternoon for the first seven days after plantation. When the plants were established, recovering from the transplanting shock, the soil in pot around the base of the plant was loosened with the help of khurpi (nirani). Adequate moisture content

(18-20% of the soil) in the pot was maintained by sprinkling water to the soil at every alternate day.

3.2.9. Preparation of inoculum and inoculation

Eggmass was collected from the roots of tomato plants as previously inoculated individually with a single eggmass of *Meloidogyne javanica*. For inoculation, nine reddish brown mature eggmasses were placed in each pot around the standing plant in 3 holes (2.5cm deep), three eggmasses on each side of the plant. Inoculation was done on whole sets of pot plants at 44 days old seedling (after 14 days of transplanting).

3.2.10. Application of extracts as treatment in the first experiment

Standard (S) leaf extracts of Bashak, Satodrone, Bermuda grass and Mustard oil cake (MOC) were used in the following manner:

T₀ = Control (without extract)

T₁ = Bashak leaf extract (S)

T₂ = Mustard oil cake (MOC) extract (S)

T₃ = Satodrone leaf extract (S)

T₄ = Bermuda grass leaf extract (S)

3.2.11. Application of methods as treatment in the second experiment

Application methods of BAU-Biofungicide were used in the following manner:

T₀ = Control without BAU-Biofungicide

T₁ = Seed treatment with BAU-Biofungicide

T₂ = Root dipping with BAU-Biofungicide

T₃ = Soil drenching with BAU-Biofungicide

T₄ = Foliar spray with BAU-Biofungicide

3.2.12. Design of experiment

It consisted of 180 (135+45) pots in two sets of pot experiment. In first experiment, 45 seedlings were dipped into the prepared plant leaf extracts and

Mustard oil cake before transplanting. Then the plant leaf extracts and the MOC extract were applied as soil drenching around the root region of other 45 seedlings of tomato plants in pots after 7 days of transplanting (before 7 days of inoculation). After that rest 45 seedlings in pots were sprayed with the plant leaf extracts and MOC extract after 7 days of transplanting (before 7 days of inoculation).

In second experiment, 9 seedlings were transplanted in pots whose seeds were treated with BAU-Biofungicide before sowing in the seed bed. Then roots of other 9 seedlings were dipped into the BAU-Biofungicide solution for 15 minutes at the time of transplanting. Next, BAU-Biofungicide was applied as soil drenching around the root region of another 9 seedlings after 7 days of transplanting (before 7 days of inoculation). At last, rest 9 seedlings in pots were sprayed with the BAU-Biofungicide solution after 7 days of transplanting (before 7 days of inoculation).

All the pots were arranged in Completely Randomized Design (CRD) in the nethouse, Department of Plant Pathology, HSTU, Dinajpur. In the first experiment, standard leaf extracts of Bashak, Satodrone, Bermuda grass and Mustard oil cake extract were used as treatment. In the second experiment, BAU-Biofungicide was used as Seed treatment, Root dipping, Soil drenching and Foliar spray. In fine, 5 treatments including control were maintained in 1st and 2nd experiment, separately. Each treatment was replicated three times in each experiment.

3.2.13. Recording temperature, humidity and soil moisture

Data on average air temperature and relative humidity were recorded daily during the experimental period in the pot experiment. The soil moisture was determined by oven dry method.

3.2.14. Parameters studied

After 30, 60, 90 days of inoculation, plants were uprooted carefully to study the following characters:

- (i) Length of shoot (cm)
- (ii) Length of root (cm)
- (iii) Fresh weight of shoot (g)
- (iv) Fresh weight of root (g)
- (v) Number of gall/g fresh root
- (vi) Number of fruit/plant
- (vii) Weight of fruit/plant (g)



3.2.15. Measurement of length of shoot and root and fresh weight of shoot and root

At first the soil of the pot was watered to make it moist for easy uprooting of the plant. Then the whole plant along with the soil attached to its root was lifted from the pot and dipped in a bucket of water. Then the roots were separated from the soil with gradual movement of roots in water. It was further cleaned under gently running tap water and carefully washed out. The length of shoot was measured from the base of the stem to the growing point of the youngest leaf after separating the root portion from the base of the stem. Similarly, length of the root was measured from the starting point of root to the longest available lateral root apex. The shoot and root portions were blotted dry with tissue papers and fresh weight was recorded by electrical balance before the materials could get dried.

3.2.16. Counting of gall, fruit number and recording of fruit weight

After washing, the roots were preserved in 5% formalin solution. The roots were cut into small pieces of 1 cm size and randomly one gram of root was taken from the bulk to count the number of galls formed in the root. After plucking fruits, fruit number and fruit weight were recorded per plant.

3.2.17. Statistical analysis

Data on the length of shoot and root, fresh weight of shoot and root, number of gall/ g of fresh root, number and weight of fruit per plant for each treatment were analyzed statistically to find out the level of significance. The means for all the treatments were counted and the analysis of the variance was studied by F-test for the treatment means and replication means. The mean differences were evaluated at $P = 0.05$ level by Duncan's New Multiple Range Test (DMRT).

CHAPTER 4

RESULTS

4.1. Experiment No. 1

4.1.1. Effect of root dipping in four plant extracts on the incidence of root gall, plant growth and fruit yield of tomato inoculated with eggmasses of *Meloidogyne javanica* is shown in Table 1.

4.1.1.1. Gallling incidence

After 30 days of inoculation (DAI) with *Meloidogyne javanica*, maximum number 30.00 of galls per gram of root was recovered from tomato plants grown in pots under control, where no plant extract was used. Treatments with extracts of Bashak leaf, Mustard oil cake, Satodrone leaf and Bermuda grass leaf reduced the gall number to 7.50, 11.50, 17.00 and 22.33 /g root. The reduction was significant as compared to control. The effectiveness of four plant extracts to reduce the galling incidence in root of tomato was significant (Table 1).

4.1.1.2. Shoot and root length

Shoot and root length of tomato was 15.67 and 6.00 cm under control, respectively. The parameters were increased to 24.67-39.25 and 16.67-31.00 cm, respectively due to root dipping in different plant extracts. The increase was significant under all treatments as compared to control. The highest increase in shoot and root length was obtained with Bashak leaf extract, which was followed by extracts of Mustard oil cake, Satodrone leaf and Bermuda grass leaf. Effect of the treatments on shoot and root length was significantly different (Table 1).

Table 1. Effect of root dipping in plant extract on root gall and plant growth of tomato after 30 days of inoculation with *Meloidogyne javanica*

Plant extract	Gall no./g root	Shoot length (cm/plant)	Root length (cm/plant)	Shoot weight (g/plant)	Root weight (g/plant)	Fruit no./plant	Fruit weight (g/plant)
Control	30.00 a	15.67 e	6.00 e	11.67 e	5.00 d	2.00 d	60 d
Bashak leaf	7.50 e	39.25 a	31.00 a	34.50 a	24.00 a	6.00 a	260 a
Mustard oil cake	11.50 d	34.50 b	26.50 b	30.50 b	20.00 b	4.50 b	210 b
Satodrone leaf	17.00 c	30.67 c	23.00 c	26.67 c	17.67 b	3.33 c	150 c
Bermuda grass leaf	22.33 b	24.67 d	16.67 d	21.67 d	12.67 c	3.00 cd	100 d

Figures are averages of three observations and those within the same column with a common letter(s) do not differ significantly ($p=0.05$)

4.1.1.3. Shoot and root weight

At 30 days after inoculation, the lowest shoot and root weight of 11.67 and 5.00 g, respectively were observed under control. Root dipping in all four plant extracts gave significant increase in both the parameters over control showing 21.67-34.50 g shoot weight and 12.67-24.00 g root weight per plant. The highest increase was obtained with extract of Bashak leaf, which was followed by Mustard oil cake, Satodrone leaf and Bermuda grass leaf (Table 1).

4.1.1.4. Fruit number and yield (weight)

Tomato plants without root dipping (control) yielded average of 2.00 fruits/plant weighing 60 g/plant. Other than Bermuda grass leaf extract, root dipping with all other three extracts gave significant increase in both parameters over control showing 3.00-6.00 fruit number and 100-260 g fruit weight per plant. Maximum increase was obtained with extract of Bashak leaf, which was followed by Mustard oil cake, Satodrone leaf and Bermuda grass leaf. But statistically no significant difference was found between control and treatment with Bermuda grass leaf in fruit number and fruit weight/plant (Table 1).

4.1.2. Effect of soil drenching in four plant extracts on the incidence of root gall, plant growth and fruit yield of tomato inoculated with eggmasses of *Meloidogyne javanica* is shown in Table 2.

4.1.2.1. Gallling incidence

After 30 days of inoculation (DAI) with *Meloidogyne javanica*, maximum number 35.00 of galls per gram of root was recovered from tomato plants grown in pots under control, where no plant extract was used. Treatments with extracts of Bashak leaf, Mustard oil cake, Satodrone leaf and Bermuda grass leaf reduced the gall number to 7.75, 12.50, 19.00 and 22.33 /g root. The reduction was significant as compared to control. The effectiveness of four plant extracts to reduce the galling incidence in root of tomato was significant (Table 2).

Table 2. Effect of soil drenching in plant extract on root gall and plant growth of tomato after 30 days of inoculation with *Meloidogyne javanica*

Plant extract	Gall no./g root	Shoot length (cm/plant)	Root length (cm/plant)	Shoot weight (g/plant)	Root weight (g/plant)	Fruit no./plant	Fruit weight (g/plant)
Control	35.00 a	14.33 e	5.67 e	10.33 e	4.67 e	2.00 c	70 c
Bashak leaf	7.75 c	37.25 a	29.00 a	32.25 a	22.25 a	5.75 a	260 a
Mustard oil cake	12.50 d	33.50 b	24.50 b	29.00 b	19.50 b	4.50 b	220 b
Satodrone leaf	19.00 c	28.33 c	20.67 c	24.33 c	15.67 c	2.33 c	100 c
Bermuda grass leaf	23.33 b	22.67 d	14.33 d	20.33 d	11.67 d	2.33 c	110 c

Figures are averages of three observations and those within the same column with a common letter(s) do not differ significantly ($p=0.05$)

4.1.2.2. Shoot and root length

Shoot and root length of tomato was 14.33 and 5.67 cm under control, respectively. The parameters were increased to 22.67-37.25 and 14.33-29.00 cm, respectively due to soil drenching in different plant extracts. The increase was significant under all treatments as compared to control. The highest increase in shoot and root length was obtained with Bashak leaf extract, which was followed by extracts of Mustard oil cake, Satodrone leaf and Bermuda grass leaf. Effect of the treatments on shoot and root length was significantly different (Table 2).

4.1.2.3. Shoot and root weight

At 30 days after inoculation, the lowest shoot and root weight of 10.33 and 4.67 g, respectively were observed under control. Soil drenching in all four plant extracts gave significant increase in both the parameters over control showing 20.33-32.25 g shoot weight and 11.67-22.25 g root weight per plant. The highest increase was obtained with extract of Bashak leaf, which was followed by Mustard oil cake, Satodrone leaf and Bermuda grass leaf (Table 2).

4.1.2.4. Fruit number and yield (weight)

Tomato plants without soil drenching (control) yielded average of 2.00 fruits/plant weighing 70 g/plant. Other than Bermuda grass leaf and Satodrone leaf extracts, soil drenching with other two extracts gave significant increase in both parameters over control showing 2.33-5.75 fruit number and 110-260 g fruit weight per plant. Maximum increase was obtained with extract of Bashak leaf, which was followed by Mustard oil cake, Satodrone leaf and Bermuda grass leaf. But statistically no significant difference was found between control and treatments with Bermuda grass leaf and Satodrone leaf in fruit number and fruit weight/plant (Table 2).

4.1.3. Effect of foliar spray in four plant extracts on the incidence of root gall, plant growth and fruit yield of tomato inoculated with eggmasses of *Meloidogyne javanica* is shown in Table 3.

4.1.3.1. Gallling incidence

After 30 days of inoculation (DAI) with *Meloidogyne javanica*, maximum number 36.00 of galls per gram of root was recovered from tomato plants grown in pots under control, where no plant extract was used. Treatments with extracts of Bashak leaf, Mustard oil cake, Satodrone leaf and Bermuda grass leaf reduced the gall number to 8.00, 13.50, 19.33 and 22.67 /g root. The reduction was significant as compared to control. The effectiveness of four plant extracts to reduce the galling incidence in root of tomato was significant (Table 3).

4.1.3.2. Shoot and root length

Shoot and root length of tomato was 15.33 and 5.33 cm under control, respectively. The parameters were increased to 22.33-35.75 and 14.33-27.50 cm, respectively due to foliar spray in different plant extracts. The increase was significant under all treatments as compared to control. The highest increase in shoot and root length was obtained with Bashak leaf extract, which was followed by extracts of Mustard oil cake, Satodrone leaf and Bermuda grass leaf. Effect of the treatments on shoot and root length was significantly different (Table 3).

4.1.3.3. Shoot and root weight

At 30 days after inoculation, the lowest shoot and root weight of 11.33 and 5.67 g, respectively were observed under control. Foliar spray in all four plant extracts gave significant increase in both the parameters over control showing 19.33-30.75 g shoot weight and 11.33-21.00 g root weight per plant. The highest increase was obtained with extract of Bashak leaf, which was followed by Mustard oil cake, Satodrone leaf and Bermuda grass leaf (Table 3).

Table 3. Effect of foliar spray in plant extract on root gall and plant growth of tomato after 30 days of inoculation with *Meloidogyne javanica*

Plant extract	Gall no./g root	Shoot length (cm/plant)	Root length (cm/plant)	Shoot weight (g/plant)	Root weight (g/plant)	Fruit no./ plant	Fruit weight (g/plant)
Control	36.00 a	15.33 e	5.33 e	11.33 e	5.67 d	2.10 d	50 d
Bashak leaf	8.00 e	35.75 a	27.50 a	30.75 a	21.00 a	7.25 a	300 a
Mustard oil cake	13.50 d	31.50 b	22.50 b	27.00 b	17.50 b	6.00 b	260 b
Satodrone leaf	19.33 c	27.33 c	19.33 c	23.00 c	14.33 c	3.33 c	160 c
Bermuda grass leaf	23.67 b	22.33 d	14.33 d	19.33 d	11.33 c	2.33 d	90 d

Figures are averages of three observations and those within the same column with a common letter(s) do not differ significantly ($p=0.05$)

4.1.3.4. Fruit number and yield (weight)

Tomato plants without foliar spray (control) yielded average of 2.10 fruits/plant weighing 50 g/plant. Other than Bermuda grass leaf extract, foliar spray with all other three extracts gave significant increase in both parameters over control showing 2.33-7.25 fruit number and 90-300 g fruit weight per plant. Maximum increase was obtained with extract of Bashak leaf, which was followed by Mustard oil cake, Satodrone leaf and Bermuda grass leaf. But statistically no significant difference was found between control and treatment with Bermuda grass leaf in fruit number and fruit weight/plant (Table 3).

4.1.4. Effect of root dipping in four plant extracts on the incidence of root gall, plant growth and fruit yield of tomato inoculated with eggmasses of *Meloidogyne javanica* is shown in Table 4.

4.1.4.1. Gallling incidence

After 60 days of inoculation (DAI) with *Meloidogyne javanica*, maximum number 41.00 of galls per gram of root was recovered from tomato plants grown in pots under control, where no plant extract was used. Treatments with extracts of Bashak leaf, Mustard oil cake, Satodrone leaf and Bermuda grass leaf reduced the gall number to 10.00, 15.67, 21.67 and 28.33 /g root. The reduction was significant as compared to control. The effectiveness of four plant extracts to reduce the galling incidence in root of tomato was significant (Table 4).

4.1.4.2. Shoot and root length

Shoot and root length of tomato was 44.00 and 26.67 cm under control, respectively. The parameters were increased to 54.00-70.00 and 36.67-52.67 cm, respectively due to root dipping in different plant extracts. The increase was significant under all treatments as compared to control. The highest increase in shoot and root length was obtained with Bashak leaf extract, which

Table 4. Effect of root dipping in plant extract on root gall and plant growth of tomato after 60 days of inoculation with *Meloidogyne javanica*

Plant extract	Gall no./g root	Shoot length (cm/plant)	Root length (cm/plant)	Shoot weight (g/plant)	Root weight (g/plant)	Fruit no./ plant	Fruit weight (g/plant)
Control	41.00 a	44.00 e	26.67 e	49.33 e	26.33 d	7.00 d	350 d
Bashak leaf	10.00 c	70.33 a	52.67 a	76.33 a	52.00 a	13.00 a	910 a
Mustard oil cake	15.67 d	64.67 b	47.67 b	70.67 b	46.33 b	11.33 ab	790 ab
Satodrone leaf	21.67 c	60.00 c	42.67 c	66.00 c	41.67 b	10.33 b	720 b
Bermuda grass leaf	28.33 b	54.00 d	36.67 d	60.00 d	36.00 c	9.33 bc	650 bc

Figures are averages of three observations and those within the same column with a common letter(s) do not differ significantly ($p=0.05$)

was followed by extracts of Mustard oil cake, Satodrone leaf and Bermuda grass leaf. Effect of the treatments on shoot and root length was significantly different (Table 4).

4.1.4.3. Shoot and root weight

At 60 days after inoculation, the lowest shoot and root weight of 49.33 and 26.33 g, respectively were observed under control. Root dipping in all four plant extracts gave significant increase in both the parameters over control showing 60.00-76.33 g shoot weight and 36.00-52.00 g root weight per plant. The highest increase was obtained with extract of Bashak leaf, which was followed by Mustard oil cake, Satodrone leaf and Bermuda grass leaf (Table 4).

4.1.4.4. Fruit number and yield (weight)

Tomato plants without root dipping (control) yielded average of 7.00 fruits/plant weighing 350 g/plant. Root dipping with all other four extracts gave significant increase in both parameters over control showing 9.33-13.00 fruit number and 650-910 g fruit weight per plant. Maximum increase was obtained with extract of Bashak leaf, which was followed by Mustard oil cake, Satodrone leaf and Bermuda grass leaf. But statistically no significant difference was found among the treatments with Bermuda grass leaf, Satodrone leaf and Mustard oil cake in fruit number and fruit weight/plant (Table 4).

4.1.5. Effect of soil drenching in four plant extracts on the incidence of root gall, plant growth and fruit yield of tomato inoculated with eggmasses of *Meloidogyne javanica* is shown in Table 5.

4.1.5.1. Galling incidence

After 60 days of inoculation (DAI) with *Meloidogyne javanica*, maximum number 38.33 of galls per gram of root was recovered from tomato plants grown in pots under control, where no plant extract was used. Treatments with

Table 5. Effect of soil drenching in plant extract on root gall and plant growth of tomato after 60 days of inoculation with *Meloidogyne javanica*

Plant extract	Gall no./g root	Shoot length (cm/plant)	Root length (cm/plant)	Shoot weight (g/plant)	Root weight (g/plant)	Fruit no./ plant	Fruit weight (g/ plant)
Control	38.33 a	42.00 e	24.33 e	47.67 e	25.00 e	6.12 d	430 d
Bashak leaf	10.67 e	68.00 a	50.33 a	73.67 a	50.33 a	12.00 a	840 a
Mustard oil cake	16.33 d	62.67 b	45.00 b	68.33 b	45.67 b	11.33 a	800 a
Satodrone leaf	22.67 c	58.00 c	40.33 c	63.67 c	41.00 c	10.00 ab	710 ab
Bermuda grass leaf	29.33 b	52.00 d	34.33 d	57.67 d	35.00 d	8.67 bc	620 bc

Figures are averages of three observations and those within the same column with a common letter(s) do not differ significantly ($p=0.05$)

extract of Bashak leaf, Mustard oil cake, Satodrone leaf and Bermuda grass leaf reduced the gall number to 10.67, 16.33, 22.67 and 29.33 /g root. The reduction was significant as compared to control. The effectiveness of four plant extracts to reduce the galling incidence in root of tomato was significant (Table 5).

4.1.5.2. Shoot and root length

Shoot and root length of tomato was 42.00 and 24.33 cm under control, respectively. The parameters were increased to 52.00-68.00 and 34.33-50.33 cm, respectively due to soil drenching in different plant extracts. The increase was significant under all treatments as compared to control. The highest increase in shoot and root length was obtained with Bashak leaf extract, which was followed by extracts of Mustard oil cake, Satodrone leaf and Bermuda grass leaf. Effect of the treatments on shoot and root length was significantly different (Table 5).

4.1.5.3. Shoot and root weight

At 60 days after inoculation, the lowest shoot and root weight of 47.67 and 25.00 g, respectively were observed under control. Soil drenching in all four plant extracts gave significant increase in both the parameters over control showing 57.67-73.67 g shoot weight and 35.00-50.33 g root weight per plant. The highest increase was obtained with extract of Bashak leaf, which was followed by Mustard oil cake, Satodrone leaf and Bermuda grass leaf (Table 5).

4.1.5.4. Fruit number and yield (weight)

Tomato plants without soil drenching (control) yielded average of 6.12 fruits/plant weighing 430 g/plant. Soil drenching with all the four extracts gave significant increase in both parameters over control showing 8.67-12.00 fruit number and 620-840 g fruit weight per plant. Maximum increase was obtained with extract of Bashak leaf, which was followed by Mustard oil cake, Satodrone leaf and Bermuda grass leaf. Statistically significant difference was observed among the treatments in fruit number and fruit weight/plant (Table 5).

4.1.6. Effect of foliar spray in four plant extracts on the incidence of root gall, plant growth and fruit yield of tomato inoculated with eggmasses of *Meloidogyne javanica* is shown in Table 6.

4.1.6.1. Galling incidence

After 60 days of inoculation (DAI) with *Meloidogyne javanica*, maximum number 40.67 of galls per gram of root was recovered from tomato plants grown in pots under control, where no plant extract was used. Treatments with extracts of Bashak leaf, Mustard oil cake, Satodrone leaf and Bermuda grass leaf reduced the gall number to 10.67, 16.33, 22.67 and 29.00 /g root. The reduction was significant as compared to control. The effectiveness of four plant extracts to reduce the galling incidence in root of tomato was significant (Table 6).

4.1.6.2. Shoot and root length

Shoot and root length of tomato was 40.00 and 22.33 cm under control, respectively. The parameters were increased to 50.67-66.67 and 33.00-49.00 cm, respectively due to foliar spray in different plant extracts. The increase was significant under all treatments as compared to control. The highest increase in shoot and root length was obtained with Bashak leaf extract, which was followed by extracts of Mustard oil cake, Satodrone leaf and Bermuda grass leaf. Effect of the treatments on shoot and root length was significantly different (Table 6).

4.1.6.3. Shoot and root weight

At 60 days after inoculation, the lowest shoot and root weight of 46.00 and 23.33 g, respectively were observed under control. Foliar spray in all four plant extracts gave significant increase in both the parameters over control showing 56.33-72.33 g shoot weight and 33.33-49.33 g root weight per plant. The highest increase was obtained with extract of Bashak leaf, which was followed by Mustard oil cake, Satodrone leaf and Bermuda grass leaf (Table 6).

Table 6. Effect of foliar spray in plant extract on root gall and plant growth of tomato after 60 days of inoculation with *Meloidogyne javanica*

Plant extract	Gall no./g root	Shoot length (cm/plant)	Root length (cm/plant)	Shoot weight (g/plant)	Root weight (g/plant)	Fruit no./ plant	Fruit weight (g/ plant)
Control	40.67 a	40.00 e	22.33 e	46.00 d	23.33 e	5.67 d	410 d
Bashak leaf	10.67 e	66.67 a	49.00 a	72.33 a	49.33 a	12.67 a	870 a
Mustard oil cake	16.33 d	61.33 b	43.67 b	67.00 b	44.00 b	11.33 b	800 ab
Satodrone leaf	22.67 c	56.67 c	39.00 c	62.33 b	39.33 c	11.33 b	720 b
Bermuda grass leaf	29.00 b	50.67 d	33.00 d	56.33 c	33.33 d	8.00 c	600 c

Figures are averages of three observations and those within the same column with a common letter(s) do not differ significantly ($p=0.05$)

4.1.6.4. Fruit number and yield (weight)

Tomato plants without foliar spray (control) yielded average of 5.67 fruits/plant weighing 410 g/plant. Foliar spray with all the extracts gave significant increase in both parameters over control showing 8.00-12.67 fruit number and 600-870 g fruit weight per plant. Maximum increase was obtained with extract of Bashak leaf, which was followed by Mustard oil cake, Satodrone leaf and Bermuda grass leaf. Statistically significant difference was found among the treatments in fruit number and fruit weight/plant (Table 6).

4.1.7. Effect of root dipping in four plant extracts on the incidence of root gall, plant growth and fruit yield of tomato inoculated with eggmasses of *Meloidogyne javanica* is shown in Table 7.

4.1.7.1. Gall incidence

After 90 days of inoculation (DAI) with *Meloidogyne javanica*, maximum number 45.67 of galls per gram of root was recovered from tomato plants grown in pots under control, where no plant extract was used. Treatments with extracts of Bashak leaf, Mustard oil cake, Satodrone leaf and Bermuda grass leaf reduced the gall number to 17.00, 22.67, 29.00 and 35.33 /g root. The reduction was significant as compared to control. The effectiveness of four plant extracts to reduce the galling incidence in root of tomato was significant (Table 7).

4.1.7.2. Shoot and root length

Shoot and root length of tomato was 71.33 and 49.00 cm under control, respectively. The parameters were increased to 81.33-99.33 and 58.00-74.00 cm, respectively due to root dipping in different plant extracts. The increase was significant under all treatments as compared to control. The highest increase in shoot and root length was obtained with Bashak leaf extract, which was followed by extracts of Mustard oil cake, Satodrone leaf and Bermuda

Table 7. Effect of root dipping in plant extract on root gall and plant growth of tomato after 90 days of inoculation with *Meloidogyne javanica*

Plant extract	Gall no./g root	Shoot length (cm/plant)	Root length (cm/plant)	Shoot weight (g/plant)	Root weight (g/plant)	Fruit no./plant	Fruit weight (g/plant)
Control	45.67 a	71.33 e	49.00 e	79.00 e	63.00 e	15.67 d	1270 d
Bashak leaf	17.00 e	99.33 a	74.00 a	105.7 a	90.33 a	28.67 a	2540 a
Mustard oil cake	22.67 d	94.00 b	68.67 b	100.3 b	85.00 b	25.33 b	2150 b
Satodrone leaf	29.00 c	89.00 c	64.00 c	95.00 c	80.00 c	24.00 bc	2070 bc
Bermuda grass leaf	35.33 b	81.33 d	58.00 d	89.00 d	73.33 d	22.33 c	1910 c

Figures are averages of three observations and those within the same column with a common letter(s) do not differ significantly ($p=0.05$)

grass leaf. Effect of the treatments on shoot and root length was significantly different (Table 7).

4.1.7.3. Shoot and root weight

At 90 days after inoculation, the lowest shoot and root weight of 79.00 and 63.00 g, respectively were observed under control. Root dipping in all four plant extracts gave significant increase in both the parameters over control showing 89.00-105.70 g shoot weight and 73.33-90.33 g root weight per plant. The highest increase was obtained with extract of Bashak leaf, which was followed by Mustard oil cake, Satodrone leaf and Bermuda grass leaf (Table 7).

4.1.7.4. Fruit number and yield (weight)

Tomato plants without root dipping (control) yielded average of 15.67 fruits/plant weighing 1270 g/plant. Root dipping with all the extracts gave significant increase in both parameters over control showing 22.33-28.67 fruit number and 1910-2540 g fruit weight per plant. Maximum increase was obtained with extract of Bashak leaf, which was followed by Mustard oil cake, Satodrone leaf and Bermuda grass leaf. But statistically no significant difference was found between the treatments with Satodrone leaf and Mustard oil cake in fruit number and fruit weight/plant (Table 7).

4.1.8. Effect of soil drenching in four plant extracts on the incidence of root gall, plant growth and fruit yield of tomato inoculated with eggmasses of *Meloidogyne javanica* is shown in Table 8.

4.1.8.1. Gallling incidence

After 90 days of inoculation (DAI) with *Meloidogyne javanica*, maximum number 48.00 of galls per gram of root was recovered from tomato plants grown in pots under control, where no plant extract was used. Treatments with extracts of Bashak leaf, Mustard oil cake, Satodrone leaf and Bermuda grass leaf reduced the gall number to 18.00, 23.67, 30.00 and 36.67 /g root. The

Table 8. Effect of soil drenching in plant extract on root gall and plant growth of tomato after 90 days of inoculation with *Meloidogyne javanica*

Plant extract	Gall no./g root	Shoot length (cm/plant)	Root length (cm/plant)	Shoot weight (g/plant)	Root weight (g/plant)	Fruit no./plant	Fruit weight (g/plant)
Control	48.00 a	71.33 e	45.00 e	76.33 d	67.67 d	14.33 e	1220 e
Bashak leaf	18.00 e	97.00 a	71.67 a	102.0 a	91.67 a	26.33 a	2250 a
Mustard oil cake	23.67 d	91.67 b	66.33 b	96.67 b	88.33 ab	24.67 b	2120 b
Satodrone leaf	30.00 c	87.00 c	61.67 c	92.00 b	83.67 bc	23.33 c	1980 c
Bermuda grass leaf	36.67 b	81.33 d	55.67 d	86.33 c	77.67 c	20.67 d	1760 d

Figures are averages of three observations and those within the same column with a common letter(s) do not differ significantly ($p=0.05$)

reduction was significant as compared to control. The effectiveness of four plant extracts to reduce the galling incidence in root of tomato was significant (Table 8).

4.1.8.2. Shoot and root length

Shoot and root length of tomato was 71.33 and 45.00 cm under control, respectively. The parameters were increased to 81.33-97.00 and 55.67-71.67 cm, respectively due to soil drenching in different plant extracts. The increase was significant under all treatments as compared to control. The highest increase in shoot and root length was obtained with Bashak leaf extract, which was followed by extracts of Mustard oil cake, Satodrone leaf and Bermuda grass leaf. Effect of the treatments on shoot and root length was significantly different (Table 8).

4.1.8.3. Shoot and root weight

At 90 days after inoculation, the lowest shoot and root weight of 76.33 and 67.67 g, respectively were observed under control. Soil drenching in all four plant extracts gave significant increase in both the parameters over control showing 86.33-102.00 g shoot weight and 77.67-91.67 g root weight per plant. The highest increase was obtained with extract of Bashak leaf, which was followed by Mustard oil cake, Satodrone leaf and Bermuda grass leaf (Table 8).

4.1.8.4. Fruit number and yield (weight)

Tomato plants without soil drenching (control) yielded average of 14.33 fruits/plant weighing 1220 g/plant. Soil drenching with all the extracts gave significant increase in both parameters over control showing 20.67-26.33 fruit number and 1760-2250 g fruit weight per plant. Maximum increase was obtained with extract of Bashak leaf, which was followed by Mustard oil cake, Satodrone leaf and Bermuda grass leaf. Statistically significant difference was found among the treatments in fruit number and fruit weight/plant (Table 8).

4.1.9. Effect of foliar spray in four plant extracts on the incidence of root gall, plant growth and fruit yield of tomato inoculated with eggmasses of *Meloidogyne javanica* is shown in Table 9.

4.1.9.1. Gallling incidence

After 90 days of inoculation (DAI) with *Meloidogyne javanica*, maximum number 48.00 of galls per gram of root was recovered from tomato plants grown in pots under control, where no plant extract was used. Treatments with extracts of Bashak leaf, Mustard oil cake, Satodrone leaf and Bermuda grass leaf reduced the gall number to 17.33, 24.67, 31.00 and 37.33 /g root. The reduction was significant as compared to control. The effectiveness of four plant extracts to reduce the galling incidence in root of tomato was significant (Table 9).

4.1.9.2. Shoot and root length

Shoot and root length of tomato was 69.67 and 44.33 cm under control, respectively. The parameters were increased to 79.67-95.67 and 54.33-70.33 cm, respectively due to foliar spray in different plant extracts. The increase was significant under all treatments as compared to control. The highest increase in shoot and root length was obtained with Bashak leaf extract, which was followed by extracts of Mustard oil cake, Satodrone leaf and Bermuda grass leaf. Effect of the treatments on shoot and root length was significantly different (Table 9).

4.1.9.3. Shoot and root weight

At 90 days after inoculation, the lowest shoot and root weight of 74.33 and 63.67 g, respectively were observed under control. Foliar spray in all four plant extracts gave significant increase in both the parameters over control showing 84.33-100.30 g shoot weight and 74.33-90.33 g root weight per plant. The highest increase was obtained with extract of Bashak leaf, which was followed by Mustard oil cake, Satodrone leaf and Bermuda grass leaf (Table 9).

Table 9. Effect of foliar spray in plant extract on root gall and plant growth of tomato after 90 days of inoculation with *Meloidogyne javanica*

Plant extract	Gall no./g root	Shoot length (cm/plant)	Root length (cm/plant)	Shoot weight (g/plant)	Root weight (g/plant)	Fruit no./ plant	Fruit weight (g/ plant)
Control	48.00 a	69.67 e	44.33 e	74.33 e	63.67 d	14.33 c	1110 d
Bashak leaf	17.33 e	95.67 a	70.33 a	100.3 a	90.33 a	25.00 a	2150 a
Mustard oil cake	24.67 d	90.33 b	65.00 b	95.00 b	85.00 ab	23.33 b	1990 b
Satodrone leaf	31.00 c	85.67 c	60.33 c	90.33 c	80.33 bc	22.00 c	1960 b
Bermuda grass leaf	37.33 b	79.67 d	54.33 d	84.33 d	74.33 c	20.33 d	1670 c

Figures are averages of three observations and those within the same column with a common letter(s) do not differ significantly ($p=0.05$)

4.1.9.4. Fruit number and yield (weight)

Tomato plants without foliar spray (control) yielded average of 14.33 fruits/plant weighing 60 g/plant. Foliar spray with all the extracts gave significant increase in both parameters over control showing 20.33-25.00 fruit number and 1670-2150 g fruit weight per plant. Maximum increase was obtained with extract of Bashak leaf, which was followed by Mustard oil cake, Satodrone leaf and Bermuda grass leaf. But statistically no significant difference was found between Mustard oil cake and Satodrone leaf in fruit weight/plant (Table 9).

4.2. Experiment No. 2

4.2.1. Effect of BAU-Biofungicide in four methods on the incidence of root gall, plant growth and fruit yield of tomato inoculated with eggmasses of *Meloidogyne javanica* is shown in Table 10.

4.2.1.1. Gallling incidence

After 30 days of inoculation (DAI) with *Meloidogyne javanica*, maximum number 24.33 of galls per gram of root was recovered from tomato plants grown in pots under control, where no BAU-Biofungicide was applied. Soil drenching, Seed treatment, Root dipping, and Foliar spray with BAU-Biofungicide reduced the gall number to 2.33, 4.00, 5.00 and 5.67 /g root. The reduction was significant as compared to control. The effectiveness of the four treatments to reduce the galling incidence in root of tomato was significant (Table 10).

4.2.1.2. Shoot and root length

Shoot and root length of tomato was 14.67 and 7.67 cm under control, respectively. The parameters were increased to 27.67-44.67 and 17.33-33.67 cm, respectively due to BAU-Biofungicide in different treatments. The increase was significant under all treatments as compared to control. The highest

Table 10. Effect of BAU-Biofungicide in four methods on root gall and plant growth of tomato after 30 days of inoculation with *Meloidogyne javanica*

Treatments	Gall no./g root	Shoot length (cm/plant)	Root length (cm/plant)	Shoot weight (g/plant)	Root weight (g/plant)	Fruit no./ plant	Fruit weight (g/ plant)
Control (without BAU-Biofungicide)	24.33 a	14.67 e	7.67 e	14.67 e	5.67 e	2.33 d	70 d
Seed treatment (with BAU-Biofungicide)	4.00 c	36.33 b	24.67 b	37.67 b	21.67 b	6.67 b	240 b
Root dipping (with BAU-Biofungicide)	5.00 b	31.33 c	20.00 c	33.00 c	18.67 c	5.33 c	210 b
Soil drenching (with BAU-Biofungicide)	2.33 d	44.67 a	33.67 a	46.67 a	30.33 a	8.67 a	350 a
Foliar spray (with BAU-Biofungicide)	05.67 b	27.67 d	17.33 d	27.33 d	14.33 d	4.67 c	150 c

Figures are averages of three observations and those within the same column with a common letter(s) do not differ significantly ($p=0.05$)

increase in shoot and root length was obtained with Soil drenching, which was followed by Seed treatment, Root dipping, and Foliar spray. Effect of the treatments on shoot and root length was significantly different (Table 10).

4.2.1.3. Shoot and root weight

At 30 days after inoculation, the lowest shoot and root weight of 14.67 and 5.67 g, respectively were observed under control. BAU-Biofungicide in all four treatments gave significant increase in both the parameters over control showing 27.33-46.67 g shoot weight and 14.33-30.33 g root weight per plant. The highest increase was obtained with Soil drenching, which was followed by Seed treatment, Root dipping, and Foliar spray (Table 10).

4.2.1.4. Fruit number and yield (weight)

Tomato plants without BAU-Biofungicide (control) yielded average of 2.33 fruits/plant weighing 70 g/plant. BAU-Biofungicide with all the treatments gave significant increase in both parameters over control showing 4.67-8.67 fruit number and 150-350 g fruit weight per plant. Maximum increase was obtained with Soil drenching, which was followed by Seed treatment, Root dipping, and Foliar spray. But statistically no significant difference was found between Root dipping and Foliar spray in fruit number and between Seed treatment and Root dipping in fruit weight/plant (Table 10).

4.2.2. Effect BAU-Biofungicide in four methods on the incidence of root gall, plant growth and fruit yield of tomato inoculated with eggmasses of *Meloidogyne javanica* is shown in Table 11.

4.2.2.1. Gallling incidence

After 60 days of inoculation (DAI) with *Meloidogyne javanica*, maximum number 29.33 of galls per gram of root was recovered from tomato plants grown in pots under control, where no BAU-Biofungicide was applied. Soil drenching, Seed treatment, Root dipping, and Foliar spray with BAU-

Table 11. Effect of BAU-Biofungicide in four methods on root gall and plant growth of tomato after 60 days of inoculation with *Meloidogyne javanica*

Treatments	Gall no./g root	Shoot length (cm/plant)	Root length (cm/plant)	Shoot weight (g/plant)	Root weight (g/plant)	Fruit no./ plant	Fruit weight (g/ plant)
Control (without BAU-Biofungicide)	29.33 a	40.33 d	21.67 e	43.67 e	24.67 e	7.33 d	490 e
Seed treatment (with BAU-Biofungicide)	11.67 c	61.67 b	40.67 b	72.67 b	50.33 b	14.67 b	1020 b
Root dipping (with BAU-Biofungicide)	12.67 c	56.00 c	38.67 c	68.67 c	44.33 c	12.33 c	930 c
Soil drenching (with BAU-Biofungicide)	5.333 d	70.33 a	50.33 a	81.67 a	60.33 a	20.67 a	1450 a
Foliar spray (with BAU-Biofungicide)	14.67 b	55.33 c	31.33 d	64.67 d	40.33 d	11.67 c	780 d

Figures are averages of three observations and those within the same column with a common letter(s) do not differ significantly ($p=0.05$)

Biofungicide reduced the gall number to 5.33, 11.67, 12.67 and 14.67 /g root. The reduction was significant as compared to control. The effectiveness of the four treatments to reduce the galling incidence in root of tomato was significant (Table 11).

4.2.2.2. Shoot and root length

Shoot and root length of tomato was 40.33 and 21.67 cm under control, respectively. The parameters were increased to 55.33-70.33 and 31.33-50.33 cm, respectively due to BAU-Biofungicide in different treatments. The increase was significant under all treatments as compared to control. The highest increase in shoot and root length was obtained with Soil drenching, which was followed by Seed treatment, Root dipping, and Foliar spray. Effect of the treatments on shoot and root length was significantly different (Table 11).

4.2.2.3. Shoot and root weight

At 60 days after inoculation, the lowest shoot and root weight of 43.67 and 24.67 g, respectively were observed under control. BAU-Biofungicide in all four treatments gave significant increase in both the parameters over control showing 64.67-81.67 g shoot weight and 40.33-60.33 g root weight per plant. The highest increase was obtained with Soil drenching, which was followed by Seed treatment, Root dipping and Foliar spray (Table 11).

4.2.2.4. Fruit number and yield (weight)

Tomato plants without BAU-Biofungicide (control) yielded average of 7.33 fruits/plant weighing 490 g/plant. BAU-Biofungicide with all the treatments gave significant increase in both parameters over control showing 11.67-20.67 fruit number and 780-1450 g fruit weight per plant. Maximum increase was obtained with Soil drenching, which was followed by Seed treatment, Root dipping, and Foliar spray. But statistically no significant difference was found between Root dipping and Foliar spray in fruit number (Table 11).

4.2.3. Effect of BAU-Biofungicide in four methods on the incidence of root gall, plant growth and fruit yield of tomato inoculated with eggmasses of *Meloidogyne javanica* is shown in Table 12.

4.2.3.1. Gallings incidence

After 90 days of inoculation (DAI) with *Meloidogyne javanica*, maximum number 44.33 of galls per gram of root was recovered from tomato plants grown in pots under control, where no BAU-Biofungicide was applied. Soil drenching, Seed treatment, Root dipping, and Foliar spray with BAU-Biofungicide reduced the gall number to 9.33, 16.33, 17.67 and 20.33 /g root. The reduction was significant as compared to control. The effectiveness of the four treatments to reduce the galling incidence in root of tomato was significant (Table 12).

4.2.3.2. Shoot and root length

Shoot and root length of tomato was 65.33 and 34.67 cm under control, respectively. The parameters were increased to 79.33-98.67 and 49.67-70.33 cm, respectively due to BAU-Biofungicide in different treatments. The increase was significant under all treatments as compared to control. The highest increase in shoot and root length was obtained with Soil drenching, which was followed by Seed treatment, Root dipping, and Foliar spray. Effect of the treatments on shoot and root length was significantly different (Table 12).

4.2.3.3. Shoot and root weight

At 90 days after inoculation, the lowest shoot and root weight of 71.67 and 54.67 g, respectively were observed under control. BAU-Biofungicide in all four treatments gave significant increase in both the parameters over control showing 81.67-109.70 g shoot weight and 66.67-84.67 g root weight per plant. The highest increase was obtained with Soil drenching, which was followed by Seed treatment, Root dipping, and Foliar spray (Table 12).

Table 12. Effect of BAU-Biofungicide in four methods on root gall and plant growth of tomato after 90 days of inoculation with *Meloidogyne javanica*

Treatments	Gall no./g root	Shoot length (cm/plant)	Root length (cm/plant)	Shoot weight (g/plant)	Root weight (g/plant)	Fruit no./ plant	Fruit weight (g/ plant)
Control (without BAU-Biofungicide)	44.33 a	65.33 e	34.67 e	71.67 e	54.67 e	15.67 d	1380 d
Seed treatment (with BAU-Biofungicide)	16.33 d	87.67 b	58.67 b	98.33 b	72.33 b	25.67 b	2310 b
Root dipping (with BAU-Biofungicide)	17.67 c	82.33 c	54.00 c	92.00 c	70.00 c	22.00 c	2260 b
Soil drenching (with BAU-Biofungicide)	9.33 e	98.67 a	70.33 a	109.7 a	84.67 a	34.67 a	3120 a
Foliar spray (with BAU-Biofungicide)	20.33 b	79.33 d	49.67 d	81.67 d	66.67 d	21.67 c	1930 c

Figures are averages of three observations and those within the same column with a common letter(s) do not differ significantly ($p=0.05$)

4.2.3.4. Fruit number and yield (weight)

Tomato plants without BAU-Biofungicide (control) yielded average of 15.67 fruits/plant weighing 1380 g/plant. BAU-Biofungicide with all the treatments gave significant increase in both parameters over control showing 21.67-34.67 fruit number and 1930-3120 g fruit weight per plant. Maximum increase was obtained with Soil drenching, which was followed by Seed treatment, Root dipping, and Foliar spray But statistically no significant difference was found between Root dipping and Foliar spray in fruit number and between Seed treatment and Root dipping in fruit weight/plant (Table 12).

4.3. Correlation and regression study

Correlation and regression study was done to examine the relationship of shoot and root length; shoot and root weight and fruit number and fruit weight with galling incidence under the treatments. It revealed negative and significant correlations between shoot and root length as well as shoot and root weight and fruit number and fruit weight with gall number followed in the linear regression equations ($Y = 116.43 - 0.98x$, $r = -0.99^{**}$, $Y = 88.69 - 0.86x$, $r = -0.99^{**}$, $Y = 121.53 - 0.92x$, $r = -0.99^{**}$, $Y = 106.81 - 0.95x$, $r = -0.99^{**}$, $Y = 35.84 - 0.42x$, $r = -0.95^{**}$, $Y = 3.19 - 0.04x$, $r = -0.94^{**}$, $Y = 112.14 - 0.84x$, $r = -0.99^{**}$, $Y = 87.59 - 0.88x$, $r = -0.99^{**}$, $Y = 117.14 - 0.84x$, $r = -0.99^{**}$, $Y = 107.16 - 0.81x$, $r = -0.99^{**}$, $Y = 34.20 - 0.39x$, $r = -0.96^{**}$, $Y = 2.93 - 0.03x$, $r = -0.96^{**}$, $Y = 111.15 - 0.85x$, $r = -0.99^{**}$, $Y = 85.81 - 0.85x$, $r = -0.99^{**}$, $Y = 115.79 - 0.85x$, $r = -0.99^{**}$, $Y = 106.30 - 0.87x$, $r = -0.99^{**}$, $Y = 31.69 - 0.33x$, $r = -0.93^{**}$, $Y = 2.83 - 0.03x$, $r = -0.91^{**}$, $Y = 101.21 - 0.85x$, $r = -0.88^{**}$, $Y = 73.45 - 0.92x$, $r = -0.89^{**}$, $Y = 111.89 - 0.98x$, $r = -0.79^{**}$, $Y = 85.94 - 0.75x$, $r = -0.86^{**}$, $Y = 33.58 - 0.44x$, $r = -0.72^{**}$, $Y = 3.12 - 0.05x$, $r = -0.81^{**}$) in tomato (Figures. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12). The results indicated that the treatments were effective in increasing the growth characters of tomato by suppressing the nematode activities as evident with lower galling incidence in the treated plants over control treatment.



Plate 1. Growth status of tomato plant in the first experiment after 60 days of inoculation with *M. javanica*



Plate 2. Growth status of tomato plant in the second experiment after 60 days of inoculation with *M. javanica*



Plate 3. Growth and galling incidence of tomato treated with standard (S) extract after 7 days of transplantation at 90 days of inoculation (first experiment)



Plate 4. Growth and galling incidence of tomato in four methods treated with BAU-Biofungicide after 7 days of transplantation at 90 days of inoculation (second experiment)



Plate 5. Growth and galling incidence of tomato treated with standard (S) extract after 7 days of transplantation at 90 days of inoculation (first experiment)



Plate 6. Growth and galling incidence of tomato in four methods treated with BAU-Biofungicide after 7 days of transplantation at 90 days of inoculation (second experiment)

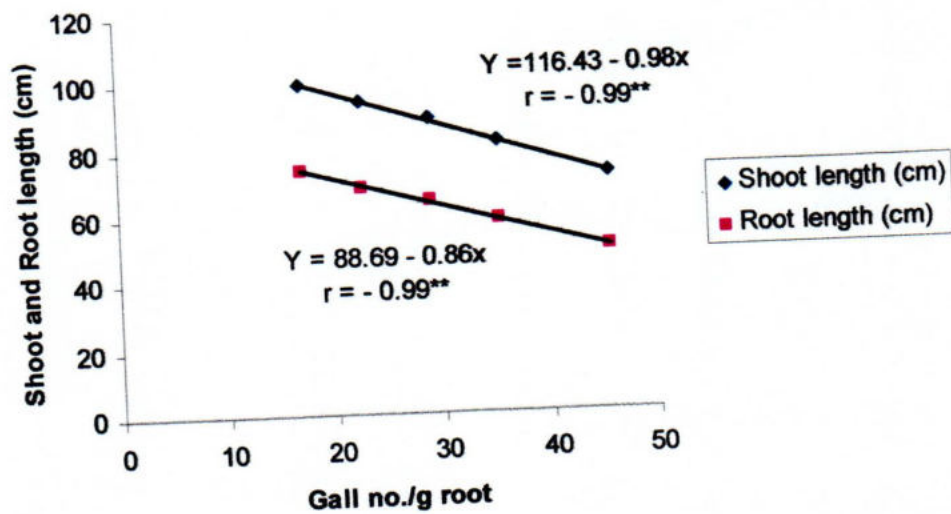


Figure 1. Relationship between shoot and root length (cm) with gall no./ g root of tomato in root dipping with botanicals on plant growth of tomato 90 days after inoculation with *Meloidogyne javanica*

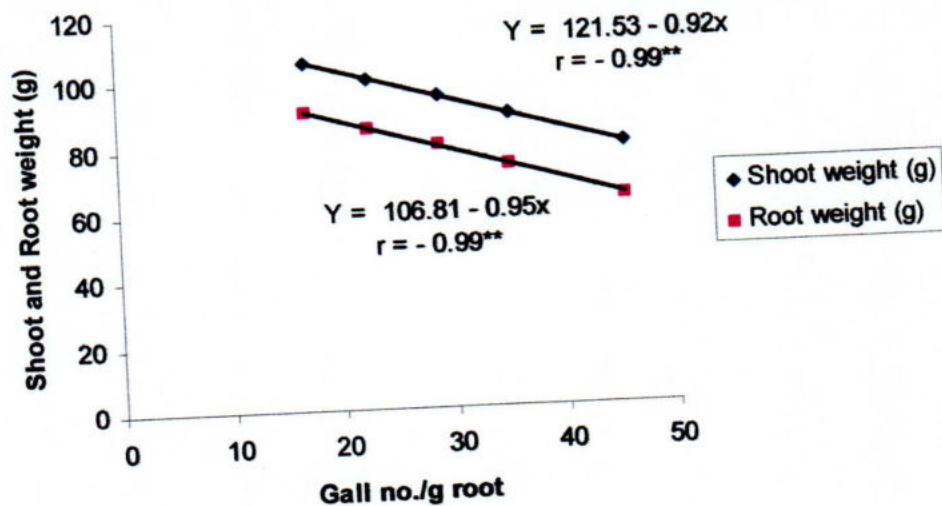


Figure 2. Relationship between shoot and root weight (g) with gall no./ g root of tomato in root dipping with botanicals on plant growth of tomato 90 days after inoculation with *Meloidogyne javanica*

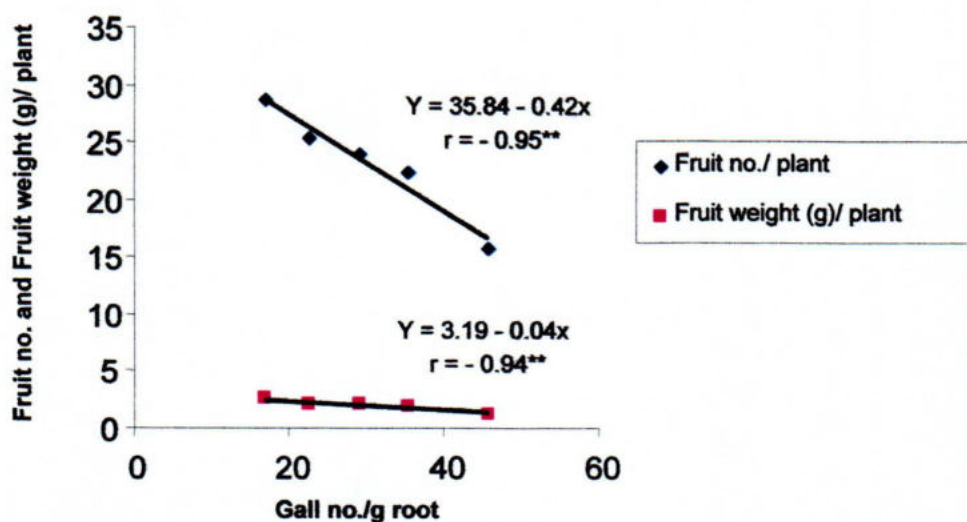


Figure 3. Relationship between fruit no. and fruit weight (g) /plant with gall no./ g root of tomato in root dipping with botanicals on plant growth of tomato 90 days after inoculation with *Meloidogyne javanica*

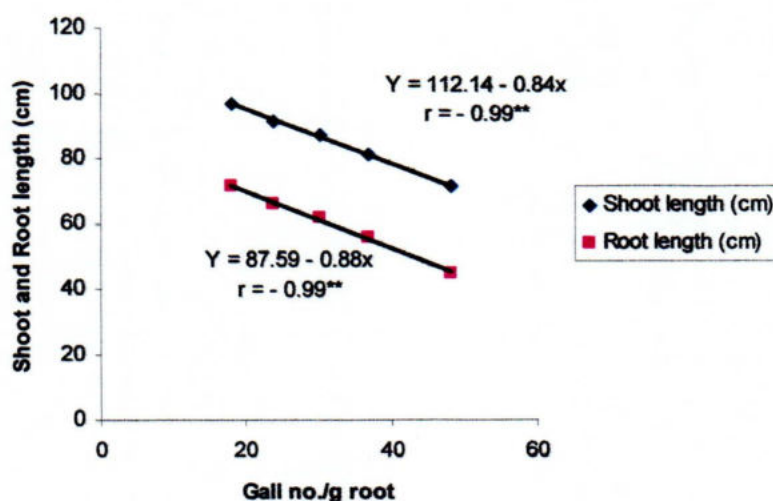


Figure 4. Relationship between shoot and root length (cm) with gall no./ g root of tomato in soil drenching with botanicals applied after 7 days of transplantation on plant growth of tomato 90 days after inoculation with *Meloidogyne javanica*

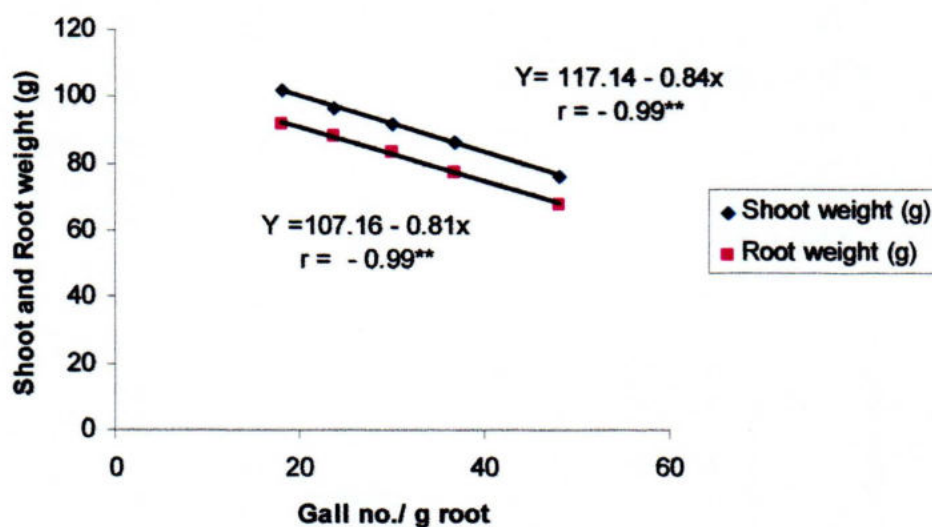


Figure 5. Relationship between shoot and root weight(g) with gall no./ g root of tomato in soil drenching with botanicals applied after 7 days of transplantation on plant growth of tomato 90 days after inoculation with *Meloidogyne javanica*

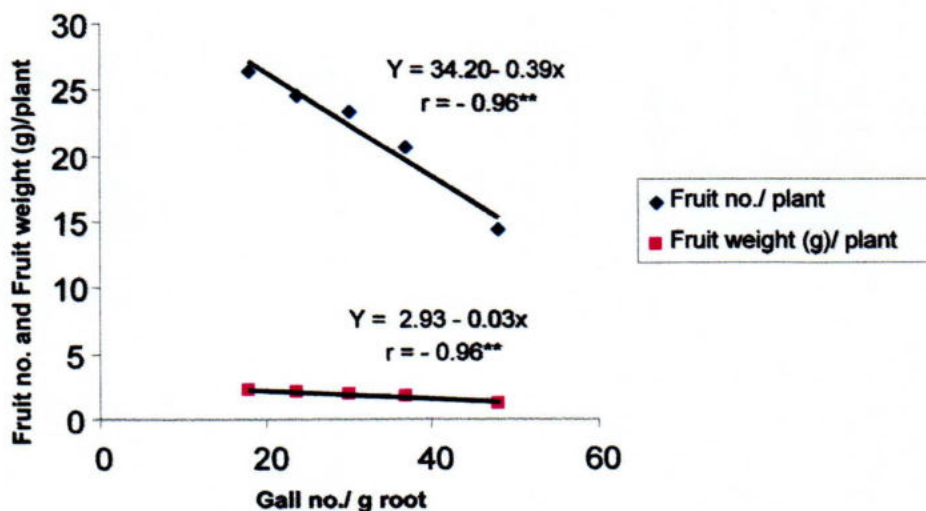


Figure 6. Relationship between fruit no. and fruit weight (g) /plant with gall no./ g root of tomato in soil drenching with botanicals applied after 7 days of transplantation on plant growth of tomato 90 days after inoculation with *Meloidogyne javanica*

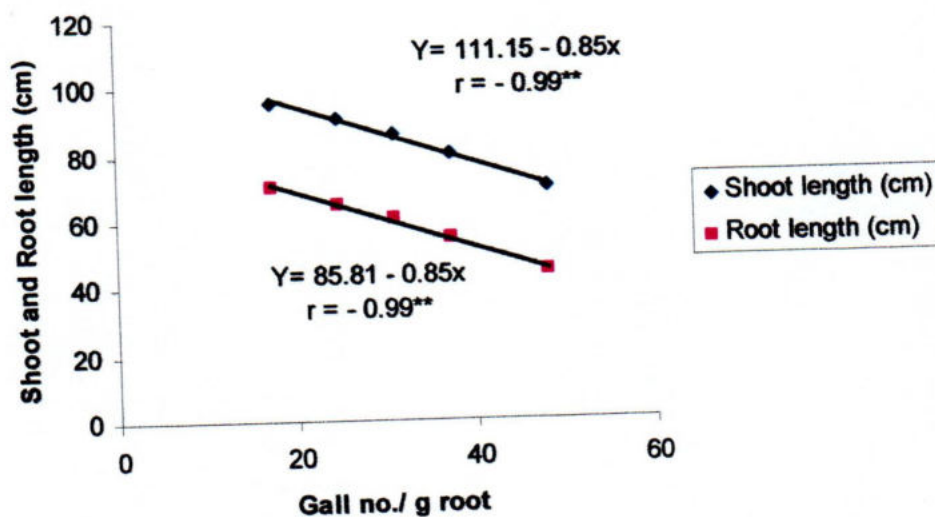


Figure 7. Relationship between shoot and root length(cm) with gall no./ g root of tomato in foliar spray with botanicals applied after 7 days of transplantation on plant growth of tomato 90 days after inoculation with *Meloidogyne javanica*

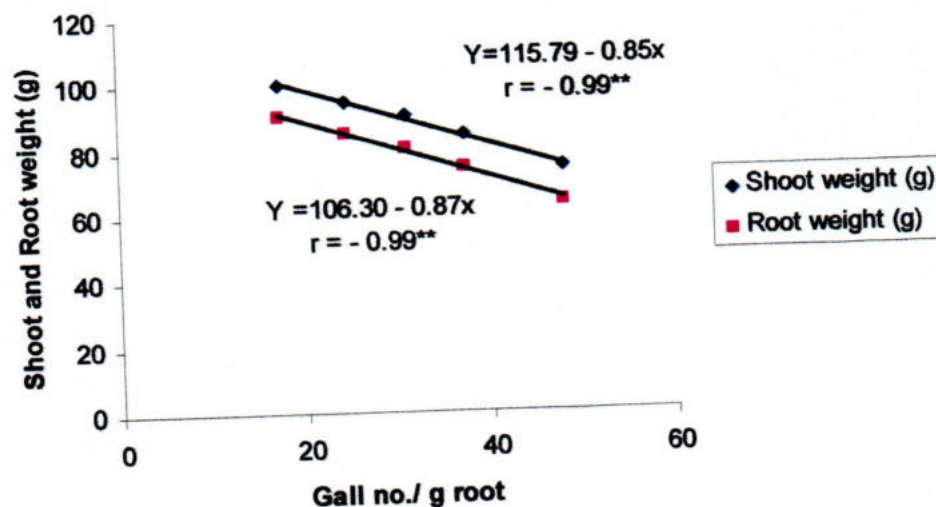


Figure 8. Relationship between shoot and root weight(g) with gall no./ g root of tomato in foliar spray with botanicals applied after 7 days of transplantation on plant growth of tomato 90 days after inoculation with *Meloidogyne javanica*

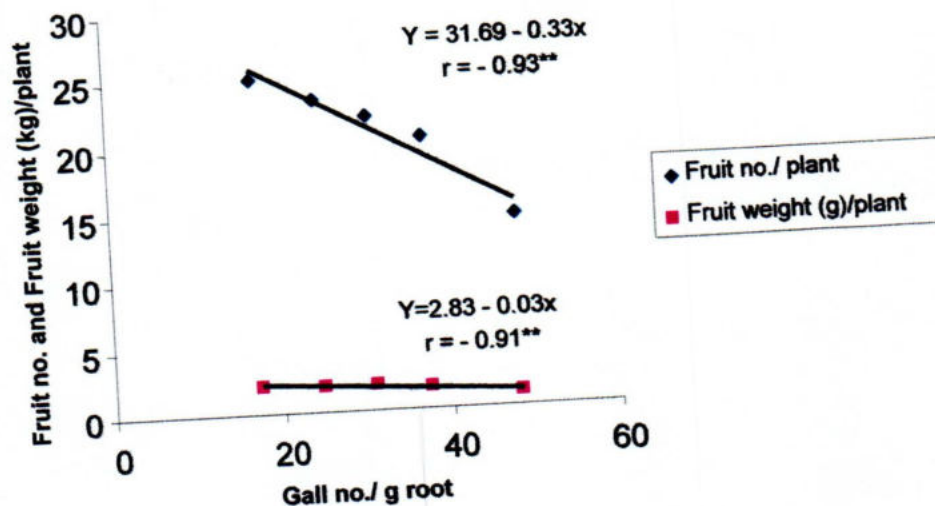


Figure 9. Relationship between fruit no. and fruit weight (g) /plant with gall no./ g root of tomato in foliar spray with botanicals applied after 7 days of transplantation on plant growth of tomato 90 days after inoculation with *Meloidogyne javanica*

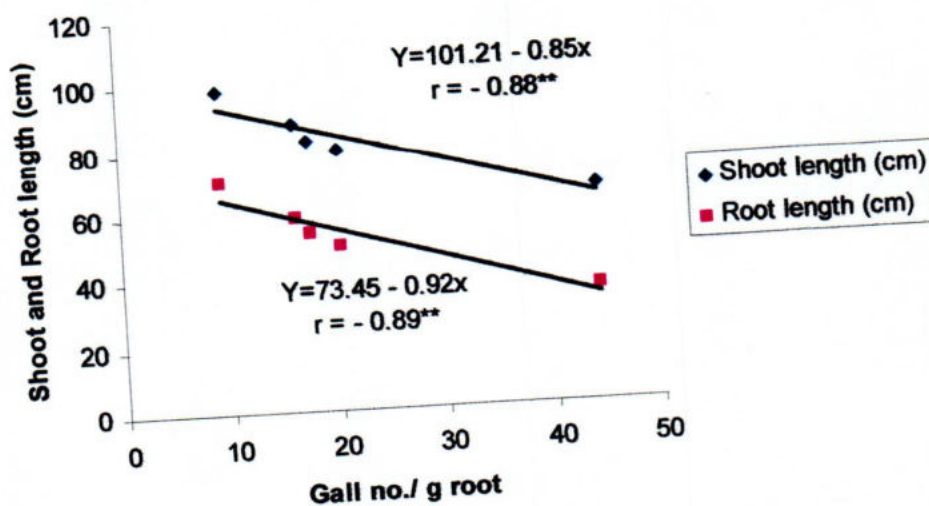


Figure 10. Relationship between shoot and root length (cm) with gall no./ g root of tomato in four methods treated with BAU-Biofungicide on plant growth of tomato after 90 days of inoculation with *Meloidogyne javanica*

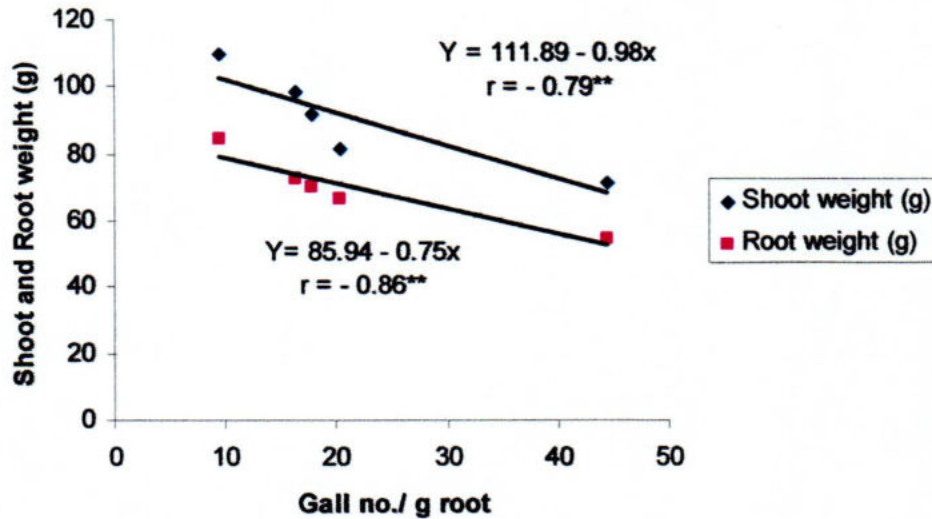


Figure 11. Relationship between shoot and root weight (g) with gall no./ g root of tomato in four methods treated with BAU-Biofungicide on plant growth of tomato after 90 days of inoculation with *Meloidogyne javanica*

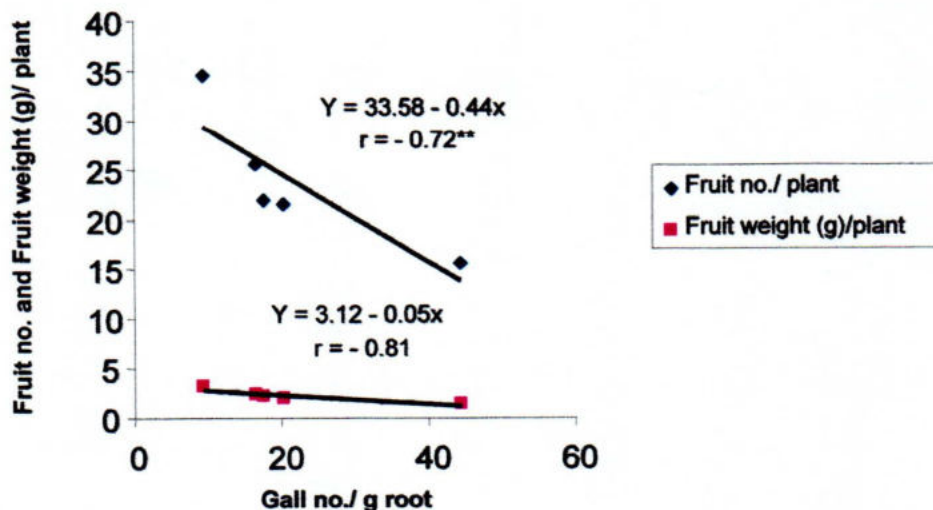


Figure 12. Relationship between fruit no. and fruit weight (g) /plant with gall no./ g root of tomato in four methods treated with BAU-Biofungicide on plant growth of tomato after 90 days of inoculation with *Meloidogyne javanica*

CHAPTER 5

DISCUSSION

In case of pot experiments (1st & 2nd Experiment), 5 treatments including control, separately showed their significant variation in plant growth characters of tomato against root-knot (*Meloidogyne javanica*) of tomato after 7 days of transplantation. All the treatments exhibited superior effect on shoot length, root length; shoot weight, root weight, fruit number, fruit weight and galling incidence compared to the control treatment (Tables 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12).

In 1st experiment all the plant extracts (Bashak, Mustard oil-cake, Satodrone and Bermuda grass) appeared to be superior by giving higher response in plant growth characters with simultaneous reduction in the nematode activities as evident with lower galling incidence than control. While working with 15 indigenous plant extracts on root-knot nematode of brinjal, Ahmad *et al.* (1990 b) found that standard plant extract (S) of shatamuli (*Asparagus officinalis*) suppressed the activity of *M. javanica* with lower galling incidence and corresponding higher growth characters of brinjal. Hassan *et al.* (2004) used solutions of oil-cakes of mustard, til and soybean to control root-knot of potato, where solution of mustard oil-cake showed the best performance followed by til oil-cake. Mustard oil-cake was found best in increasing shoot length and root length with the reduction of galling by *Meloidogyne javanica* in potato variety, Pakhri lalita.

Saifullah and Gui (1990) observed that cotton oil-cake (*Gossypium hirsutum*), castor oil-cake (*Ricinus communis*), mustard oil-cake (*Brassica campestris*), linseed oil-cake (*Linum angustifolium*) or sesame oil-cake (*Sesamum indicum*) all at 13g / pot and wheat straw or sawdust both at 8 g/ pot as soil amendments greatly suppressed populations of *Meloidogyne* spp in tomato with mustard and linseed oil-cake having the best effect. Many authors reported that leaf and

seed extracts of indigenous plants were found to be effective in controlling plant parasitic nematodes of different crop plants (Egunojobi and Afolami, 1976; Kanaujia and Mishra, 1978; Haseeb *et al.*, 1982; Nandal and Bhatti, 1986; Siddiqui and Alam, 1987; Lee, 1987; Arya and Saxena, 1988; Chhabra *et al.*, 1988; Mohanty and Das, 1988; Pathak *et al.*, 1988).

With respect to shoot and root length, shoot and root weight treatment T_1 showed higher significant response compared to the non-treated control T_0 (Tables 1, 2, 3, 4, 5, 6, 7, 8 and 9). In case of number of galls per g of root, treatments T_1 , T_2 , T_3 and T_4 appeared to give significantly lower response compared to non treated control treatment T_0 (Tables 1, 2, 3, 4, 5, 6, 7, 8 and 9) indicating the suppressing effect of the extracts on the nematode activity allowing better growth of plants.

In 2nd experiment, all the application methods of BAU-Biofungicide (Seed treatment, Root dipping, Soil drenching and Foliar spray) were evaluated against root-knot (*Meloidogyne javanica*) of tomato. Higher values of the treated plants in relation to shoot and root length, shoot and root weight, fruit number per plant as well as fruit weight per plant were recorded with the indication of better response of the treatments compared to control.

The biological control of root-knot disease caused by *Meloidogyne* spp. with BAU-Biofungicide following the methods Seed treatment, Root dipping, Soil drenching and Foliar spray had been practised by many authors. Akhtar *et al.* (1992) reported that root dip treatments with leaf extracts of Persian lilac (*Melia azedarach*) or *Calotropis procera* significantly reduced root-knot development caused by *M. incognita* on tomato and *Capsicum annum*, *C. procera* being the most effective. Nematode control and plant growth increased with extract concentration and dip duration. Bettiol (1996) reported that seed treatment with *Trichoderma* spp. controlled the soil-borne pathogen.

In another experiment, Byomakesh *et al.* (1998) conducted an experiment to evaluate the comparative efficacy of 4 neem products (neem bitter 0.5%, repolin 1%, welgrow 1% and neem seed extracts 2.5%) against *M. incognita* infecting tomato. Application by seed treatments, bare root dipping of seedling and foliar spraying proved that all the neem products were effective in reducing the root-knot disease incidence and increasing growth of plants.

Siddiqui *et al.* (1999) stated that root dip treatment with *P. aeruginosa* with or without *Trichoderma harzianum*, *T. koningii* and *T. hamatum* significantly controlled infection of roots by *Fusarium solani*, *Rhizoctonia solani* and *Meloidogyne javanica* on *C. annuum*. Combined use of *T. harzianum* with *P. aeruginosa* caused the greatest reduction in gall formation by *M. javanica*. Infection of *M. phaseolina* and *R. solani* was comparatively greater in *M. javanica* infested soil than in non-infested soil whereas *F. solani* infection was greater in non-infested soil. *P. aeruginosa* mixed with *Trichoderma* spp. also significantly increased plant growth.

Mohammad and Akhtar (2000) reported that the symptoms of root-gall caused by *M. incognita* were significantly reduced by the bare-root-dip treatment of tomato seedling in a neem based commercial product and in an aqueous extract of neem seeds. Treatments with all concentrations at various periods of dipping time reduced root-knot development. It is also investigated that improvement in plant weight and height were correlated to reduction in nematode infestation.

In another experiment, Hossain (2003) observed that neem oil as seed treatment had better response on plant growth in reducing galls and nematode development. Seed treatment with neem fruit extract gave better response followed by neem bark extract in promoting plant growth and suppressing development of the nematode. Neem leaf extract as seed treatment was found to be less effective due to lower plant growth characters with higher number of galls and juvenile populations.

Hassan *et al.* (2005 b) observed that effect of turmeric (*Curcuma longa*) in different forms viz. raw bark, dry bark, powder and extract was evaluated as soil amendment and drenching for controlling root-knot of tomato. The soil amended with turmeric in the form of raw and dry bark, powder as well as extract in lower concentration (S/100) suppressed the root-knot nematodes of tomato significantly as evident with lower galling incidence with strong positive impact on growth parameters of the tomato plant. Soil amendment with dry bark and powder of turmeric showed significantly superior influence in reducing root-knot of tomato with the increase in plant growth over the other treatments.

The results with BAU-Biofungicide revealed that maximum shoot and root length, fresh weight of shoot and root were obtained with the treatment T₃ (Soil drenching) followed by T₁ (Seed treatment), T₂ (Root dipping) and T₄ (Foliar spray as shown in tables 10, 11 and 12). On the other hand, control treatment T₀ along with *M. javanica* along was responsible for the significant reduction in respect of length of shoot and root, fresh weight of shoot and root. Moreover, highest galling incidence was also observed with this treatment.

The significant and negative correlations between gall number with shoot and root length, gall number with shoot and root weight, gall number with number of fruit per plant as well as gall number with fruit weight per plant under different treatments indicated that all the treatments were found to be effective to enhance shoot and root length, shoot and root weight, fruit number and fruit weight per plant with reduced number of galling. Hassan *et al.* (2004) stated that negative correlation between galling incidence and shoot length as well as root length indicated the positive effect of the treatments. It had also been supported by the reports made by Ahmad (1977) and Islam (1995). All these reports corroborate with the results of the present findings.

- Chowdhury, B. C. 1976. Phoshaler krimi rog. Krishi Katha. 36 : 141.
- Darekar, K. S.; Mhase, N. L. and Shelke, S. S. 1990. Effect of placement of non-edible oil seed cakes on the control of root-knot nematodes on tomato. Int. Nematol. Network Newsl. 7(1): 5-7.
- Devi, L. S. and Hassan, M. G. 2002. Effect of organic manures singly and in combination with *Trichoderma viride* against root-knot nematode (*Meloidogyne incognita*) of soybean (*Glycin max.* L.). Indian J. Nematol. 32(2): 190-192.
- Devi, L.S.; Sharma R. and Sharma, R. 2002. Effect of *Trichoderma* spp. against root-knot nematode, *Meloidogyne incognita* on tomato. Indian J. Nematol. 32(2): 227-228.
- Devila, M., Acosta, N. and Negron, J. 1999. Chitinolytic capacity of fungi isolated from agricultural soils infested with root knot nematode (*Meloidogyne* spp.) in Puerto Rico. J. Agril. Univ. Puerto- Rico. 83 (3-4) : 189-191.
- Ducusion, A. R. and Davide. R. G. 1972. *Meloidogyne incognita* and its effect on tomato yield and some methods on control. Philippine Agriculturist 55: 261-281.
- Egunjobi, O. A. and Afolami, S. O. 1976. Effect of Neem (*Azadirachta indica*) leaf extracts on populations of *Pratylenchus brachyurus* and on the growth and yield of maize. Nematol. 22(2): 125-132.
- El-Moity, T. H. A.; Ali, E. M.; El-Hamawi, M. H., El-Sharkawy, T. and Tiilikkala, K. 1998. Effect of some biological agents on reproduction of *Meloidogyne incognita* on tomato plants. Egyptian J. Agril. Res. 76(1): 51-62.

From the over all study, it was revealed that the highest plant growth character of tomato in respect of length of shoot and root, weight of shoot and root, fruit number and fruit weight per plant and reduced incidence of galling caused by *Meloidogyne javanica* were obtained with the treatment T₁ (Bashak leaf extract) and the treatment T₃ (Soil drenching with BAU-Biofungicide) in the 1st and 2nd experiment, respectively. Mustard oil-cake extract (T₂), Satodtone leaf extract (T₃) and Bermuda grass leaf extract (T₄) in the 1st experiment and Seed treatment, Root dipping and Foliar spray with BAU-Biofungicide in the 2nd experiment gave comparatively higher response in plant growth characters and reduced galling incidence compared to control indicating their nematicidal action to *Meloidogyne javanica*.

Biochemical study is needed to find out the toxic principles involved in plant extracts used in the present experiments. Further research with Mustard oil-cake extract, leaf extract of Bashak, Satodrone, Bermuda grass and BAU-Biofungicide with application methods as found promising in the present investigation should be carried out under the field conditions before any recommendation is made to the farmers.

CHAPTER 6

SUMMARY

Two sets of pot experiments (1st & 2nd experiment) were conducted to evaluate the efficacy of leaf extracts of Bashak (*Adhatoda vasica*), Satodrone (*Leucas aspera*), Bermuda grass (*Cynodon dactylon*) and Mustard (*Brassica napus*) oil cake extract on the incidence of root-knot (*Meloidogyne javanica*) in tomato following by Root dipping, Soil drenching and Foliar spray methods and to detect the superior application method of BAU-Biofungicide on the different growth stage of tomato plant inoculated with *Meloidogyne javanica* both in the laboratory and the nethouse, Department of Plant Pathology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur. The treatment T₁ (Bashak leaf extract) and the treatment T₃ (Soil drenching) in the 1st and 2nd experiment respectively gave the highest significant response in plant growth characters (like length of shoot and root, fresh weight of shoot and root) and yield (fruit number and fruit weight per plant) corresponding with lower galling incidence compared to the non-treated control treatment T₀ after 7 days of transplantation. Mustard oil-cake extract (T₂), Satodrone leaf extract (T₃) and Bermuda grass leaf extract (T₄) in the 1st experiment and Seed treatment (T₁), Root dipping (T₂) and Foliar spray (T₄) in the 2nd experiment gave comparatively higher response in plant growth characters and yield with reduced galling incidence in treated plants in all the methods. The correlation studies also revealed that there were negative correlations between galling incidence and length of shoot and root, weight of shoot and root, fruit no. and fruit yield in tomato which depicted that the treatments were effective in increasing the growth and yield of the crop by suppressing the nematode activity. There exists an ample scope to use plant extracts as well as the bio-agent, BAU-Biofungicide simultaneously in controlling root-knot disease of tomato.

LITERATURE CITED

- Ahmad, M. U. 1977. A review of plant parasitic nematodes in Bangladesh; a paper presented in a seminar in the Imperial College of Science and Technology, Univ.London,U.K.:3p.
- Ahmad, M. U. and Karim, M. R. 1991. Effect of ten indigenous plant extracts on root-knot nematodes of brinjal. Bangladesh J. Plant Pathol. 7(1 and 2):5-9
- Ahmad, M. U.; Haque, M. S.; Hossain, I. and Ashrafuzzaman, H. 1990 b. Effect of fifteen indigenous plant extracts on root-knot of brinjal. Bangladesh J. Plant Pathol. 6(1 and 2): 9-11.
- Ahmad, M. U.; Karim, M. R. and Khan, M. S. A. 1990 a. Effect of some indigenous plant extracts on juvenile mortality of *Meloidogyn javanica*.Int. Nematol. Network Newsl. 7(2): 5-7.
- Ahmad, R.; Tariq, M.; Javed, N. and Inam-ul-Haq-M. 1991. Effect of extracts of various plants on egg hatching and larval mortality of root-knot nematode, *Moloidogyne incognita*. Pakistan J. Phytopathol. 3(1): 38-42.
- Akhtar, M.; Wani, A. H. and Alam, M. M. 1992. Control of root-knot nematode with bare-root dip in leaf extracts of persian lilac and *Calotropis*. Curr. Nematol. : 3(1) 41-44.
- Alam, M. M. 1987. Pollution free control of plant parasitic nematodes by soil amendment with plant wastes. Biological Wastes 22 (1): 75-79.
- Alam, M. M. 1990. Neem in nematode control. In nematode bio-control (aspect and prospects) Delhi, India, CBS. Pub. and Distributed Pvt. Ltd.: 51-55.
- Anonymous. 1978. The sugar commission report, MIS Department, Bangladesh Sugar and Food Industries Corporation (BSFIC); 23p.

- Anonymous. 2002. FAO Production Yearbook, 1996. Basic Data Unit. Statistics Division, FAO, Rome, Italy, 54 : 139-141.
- Anonymous. 2008. Bangladesh Bureau of Statistics, Agriculture Wing [online]. In: <http://www.bbs.gov.bd> (last update 2008; accessed 18 July 2008). People's Republic of Bangladesh, Dhaka.
- Ansari, M. A.; Rupela, O. P.; Douaik, A.; Gopalakrishnan, S. and Sharma, S. B. 2002. Effect of culture filtrates of *Pseudomonas striata*, *Trichoderma harzianum*, *T. viride* and *Aspergillus awamory* on egg hatch of *Meloidogyne javanica*. Intl. J. Nematol. 12(2):131-136.
- Arya, R. and Saxena, S. K. 1988. Effect of extract of *Lantana camara* on hatching of larvae of root-knot nematode and soil amendment on nematodes population. National Aca. Sci. Letters 11(4): 105-106.
- Barman, M. and Das, P. 1998. Effect of chemical seed dressing and organic amendment alone and in combination for the management of root knot nematode, *Meloidogyne incognita* in green gram. Indian J. Nematol. 26(1): 72-76.
- Bettiol, W. 1996. Biological control of plant pathogens in Brazil: Application and Current Research. World J. Microbiol. and Biotech. 12(5): 505-510.
- Byomakesh, D.; Padhi, N. N. and Desh, B. 1998. Relative effect of neem products against root-knot nematode on tomato. Indian J. Nematol. 28: 163-167.
- Chhabra, H. K.; Grewal, P. S. and Singh, A. 1988. Efficacy of some plant extracts on root-knot nematodes (*Meloidogyne incognita*). J. Tree Sci. 7 (1): 24-25.
- Choudhury, B. 1979. Vegetables. 6th Revised Edn. National Trust, New Delhi, India:46.

- Faruk, M. I.; Rahman, M. I. and Bari, M. A. 2002. Management of root-knot nematode of tomato using *Trichoderma harzianum* and organic soil amendment. Bangladesh. J. Plant Pathol. 18(1/2): 33-37.
- Ganai, G. H.; Kaul, K. K. and Chhabra, K. K. 1992. Nematicidal action of leaf extracts of neem, mentha and parthenium against *Ditylenchus myceliophagus*. Plant Dis. Res. 7(2): 279-281.
- Gopal-Pandey, R. K.; Pandey, P.; Hemlata, G.; Pandey, H. and Pant, H. 2003. Efficacy of different levels of *Trichoderma viride* against root-knot nematode in chickpea (*Cicer arietinum* L.). Annals Plant Prot. Sci. 11(1): 101-103.
- Goswami, B. K. and Satyenldra-Singh. 2004. Fungal bioagents for management of root knot nematode in tomato. Pesticide Res. J. 16 (1): 9-12.
- Goswami, B. K. and Vijaylaksmni, K. 1986. Effect of some indigenous plant materials and oil- cake amended soil on the growth of tomato and root-knot nematode population. Annals of Agril. Res. 7(2): 363-366.
- Guzman-R. S. and Saxena R. C. 1987. Nematicidal activity of neem and its derivatives. J. Res. (Philippines) 4(1-2): 40-44 v.4 (1-2). P (40-44).
- Hafeez, U. K.; Riaz, A.; Waqar, A.; Khan, S. M. and Ahmad, S. A. 2000. Evaluation of chemical vs biological control treatments against root-knot nematode (*Meloidogyne incognita*) on tomato. Pakistan-Journal-of-Phytopathology. 12(2): 118-120
- Hameed, S. F. 1970. "Note on the effect of some organic additives on the incidence of root-knot nematodes in tomato. (*Lycopersicon esculentum* Mill)." Indian J. Agric. Sci. 40(3): 207-210.

- Haseeb, A.; Khan, A. M. and Saxena, S. K. 1982. Toxicity of leaf extracts of plants to root-knot and reniform nematodes. Indian J. Parasitol.6(1): 119-120.
- Hassan, S. M. E.; Ahmad, M. U.; Hassan, M. R.; Rahman, M. M. and Rahman, M. Sq. 2004. Effect of soil organic amendments on the control of root-knot of potato. J. Sci. Tech.2: 66-69.
- Hassan, S. M. E.; Ahmad, M. U.; Hossain, A. K. M. M.; Sikdar, M. S. I. and Hasan, M. R. 2005a. Effect of plant extrats on the root-knot (*Meloidogyne javanica*) of okra. J. Sci. Tech. 3: 105-108
- Hassan, S. M. E.; Ahmad, M. U.; Sikdar, M. S. I.; Hasan, M. R. and Rahman, M. Sq. 2005b. Effect of turmeric on root-knot of tomato. J. Sci. Tech. 2: 101-104.
- Hemlata, P.; Gopal, P.; Pant, H. and Pandey, G. 2000. Efficacy of bio-control agents for the management of root-knot namatode on chickpea. Annals of Plant Protec. Sci. 9(1): 157-179.
- Hemlata-Pant, Gopal-Pandey, Pant, H. and Pandey, G. 2002. Use of *Trichoderma harzianum* and neem cake alone and in combination on *Meloidogyne incognita* galls in chickpea.
- Homeyer, B. 1973. Curaterr, a root systemic insecticide and nematicide. Metteilungen under Biologichem Bundes anstalt fur Landund Forstwir Tschaft, Berlin-Dahlum. 151 :203.
- Hooker, W. J. 1981. Compendium of Potato Diseases. American Phytopathol. Soc.93-101.
- Hossain, S. S. 2003. Comparative efficacy of neem and Furadan 5G in controlling root-knot (*Meloidogyne javanica*) of cotton. An M.S. thesis submitted to the Dept. Plant Pathol. BAU, Mymensingh.

- Hussain, S.I.; Kumar, R.; Khan, T. and Titow, A. 1984. Effect of root-dip treatment of eggplant seedling with plant extracts, nematicides, oil- cake extracts and anthelmintic drugs on plant growth and root-knot development. Pak.J. Nematol. 2(2): 79-83.
- Irshad, M.; Saxena, S.K. and Zakiuddin. 1982. Effect of certain plant extracts on the mortality of *Rotylenchulus reniformis* and *Meloidogyne incognita*. Bangladesh J. Botany 11(2): 154-157.
- Islam, M. R. 1995. Nematicidal effect of bittergourd (*Momordica charantia*) extract in the control of root-knot of cucumber. An M.Sc. thesis submitted to the Department of Plant Pathology. Bangladesh Agricultural University, Mymensingh.
- Janathan, E. I. and Rajendran, G. 2000. Assessment of available yield loss in banana due to root-knot nematode, *Meloidogyne incognita*. Indian J. Nematol. 30(2): 162-164.
- Johnson, L. F. 1974. Extraction of oat straw, flax and amended soil to detect substances toxic to the root-knot nematode. Phytopathol. 64 (11): 1471-1473.
- Kanaujia, R. S. and Mishra, R. R. 1978. Effect of foliar application of plant extracts. Bangladesh J. Botany 7(2): 13-19.
- Kashem, M. A.; Ahmad, M. U.; Hossain, I.; Khan, A. A. and Aziz, A. 1994. Effect of garlic extract against root-knot of brinjal. Bangladesh J. Plant Pathol. 10 (1 and 2): P. 1-2.
- Kishore, H. 1969. Breeding for nematode resistance in potato. Third South East Asia Post Graduate Nematology course, India. Agric. Res. Inst., New Delhi.

- Kwok, O. C. H., Faty, P.C., Hoitink, H. A. Z. and Kuter, G. A. 1987. Interactions between bacteria and *Trichoderma harnatum* in suppression of *Rhizoctonia* damping-off in bark-compost media. *Phytopathol.* 77(8): 1206-1212.
- Lee, M. J. 1987. The effect of extract of *Melia azadirach* on *Meloidogyne incognita*. *Quarterly J. Chinese Forestry* 20 (4): 1-7.
- Mahmood, I., Saxen, S.K., and Zakiuddin. 1982. Effect of certain plant extracts on the mortality of *Rotylenchulus reniformis* and *Meloidogyne incognita*, *Bangladesh J. Bot.* 11(12) : 154-157.
- Malik, M. S.; Sangwan, N. K.; Dhindsa, K. S. and Bhatti, D. S. 1987. Nematicidal activity of extracts of *Xanthium strumarium*. *Pesticides* 21(10): 19-20.
- Mani, A.; Ahmed, S. N.; Kameswar R.P. and Dakshina Murti, V. 1986. Plant produces toxic to the citrus nematode *Tylenchulus semipenetrans* Gbb. *Int. Nematol. Network. Newsl.* 3(2): 14-15.
- Manuzca, G. A. 2001. Identification and evaluation of fungal organism as possible biocontrol agents of *Meloidogyne* spp. *Phytopathologia-Columbiana* 25(1-2):33-38.
- Mian, I. H. 1986. Plant parasitic nematodes associated with some crop species in Bangladesh. *Bangladesh J. Plant Pathol.* 2: 7-13.
- Mian, I. H. and Rodriguez-Kabana, R. 1982. Soil amendments with oil-cakes and chicken litter for control of *Meloidogyne arenaria*. *Nematropica* 12(2): 205-219.
- Mian, I.H.; Godoy, O; Shelby, R.A.; Rodriguez-Kabana, R. and Morgan-Jones, G. 1982. Chitin amendments for control of *Meloidogyne arenaria* in infested soil *Nematropica* 12(1): 71-84.

- Prot, J. C. and Kornprobst, J. M. 1983. Effect of *Azadirachta indica*, *Hannoa undulata* and *Hannoa klaineana* seed extracts on the ability of *Meloidogyne javanica* juveniles to penetrate tomato roots. Rev.-de-Nematol. 6(2): 330-332.
- Prot, J. C. and Kornprobst, J. M. 1985. Effect of quassiroid extracts from *Hannoa undulata* seed and the penetration and reproduction of *Meloidogyne javanica* on tomato. Rev.-de-Nematol. 8 (4): 383-389.
- Reddy, P. P. 1988. Chemical control of *Meloidogyne incognita* in tomato nursery. Indian J. Hort. 45(2) : 166-168.
- Reddy, P. P., Nagesh, M. and Devappa, V. 1997. Management of *Meloidogyne incognita* on tomato by integration of *Trichoderma harzianum*, *Glomus fasciculatum* and neem cake. Environmental Implication and Thrusts. Bangalore. India, 15-17 October: 349-352 pp.
- Rossner, J. and Zebitz, C. P.W. 1987. Effect of Neem products on nematodes and growth of tomato (*Lycopersicon esculentum*) plants. In Natural Pesticides from the Neem tree (*Azadirachta indica* A. Juss) and other tropical plants. Proceedings of the 3rd Int. Neem Conf. Nairobi, Kenya, 10-15 July 1986.
- Saifullah, Z. M. and Gui, A. 1990. Organic amendments as control of root-knot nematodes. Int. Nematol. Network Newsl. 7(1): 22-24.
- Sankaranarayanan, C., Hussaini, S. S., Kumar, P. S., Rangeshwaran, R.; Dhawan, S. C. and Kaushal, K. K. 1999. Antagonistic effect of *Trichoderma* and *Gliocladium* sp. against the root-knot nematode (*Meloidogyne incognita*) on sunflower. Proceedings of national symposium on rational approaches in nematode management for sustainable agriculture, India, 23-25 November, 1998. 25-27pp.

- Sartaj, A.; Tiyaqi, J. M. and Maskoor, M. 1985. Preliminary study on the nematicidal nature of two plants of the family compositae. Intl. Nematol. Network Newsl. 2(3): 19-21.
- Sartaj, A.; Tiyaqi, J. M. and Maskoor, M. 1986. Toxicity of an insect repellent plant to plant parasitic nematode. An M.Sc. thesis submitted to the Department of Plant Pathology. Bangladesh Agricultural University, Mymensingh
- Scramin., S.; Silva, H. P.; Fernandes, L. M. S. and Yan, C. A. 1987. Biological evaluation of 14 extracts of plant species on *Meloidogyne incognita* race 1. Nematol. Brasil. 11: 89-102.
- Sharma, C.; Trivedi, P. C. and Tiagi, B. 1985. Effect of green manuring on populations of *M. incognita* on muskmelon. Interl. Nematol. Network Newsl. 2(1): 7-9.
- Sharma, G. C. 1999. Nematode management in peach orchards using nematicides and oil cakes. Pest Management Hort. Ecosystems. 5(1): 38-41.
- Sharon, E., Bar-Eyal, Chet, I., Herrera-Estrella, A. Kleifeld, O. and Spigel, Y. 2001. Biological control of the root-knot nematode *Meloidogyne javanica* by *Trichoderma harzianum*. Phytopathol. 91 : 687-693.
- Siddiqui, I. A., Ehteshamul-Haque, S. and Ghaffar, A. 1999. Root-dip treatment with *Pseudomonas aeruginosa* and *Trichoderma* spp., in the control of root rot-root-knot disease complex in chilli (*Capsicum annum* L.). Pakistan J. Nematol. 17(1): 67-75.
- Siddiqui, M. A. and Alam, M. M. 1987. Efficacy of seed dressing with extracts of Neem and Persian lilac against *Meloidogyne incognita* and *Rotylenchulus reniformis*. Nematol. Medit. 15(2): 399-403.

- Siddiqui, M. A. and Alam, M. M. 2001. Efficacy of seed dressing with extracts of neem and persian lilac against *Meloidogyne incognita* and *Rotylenchulus reniformis*. Nematol. Medit. 15(2): 399-403.
- Spiegel, Y. and Chet, I. 1998. Evaluation of *Trichoderma* spp. as a bio-control agent against soil borne fungi and plant parasitic nematodes in Israel. Integrated Pest Management Review 3(3): 169-175.
- Stephan, A., Zuhair, M. and Al-Askari Ali. 1989. Effect of *Haplophyllum tuberculatum* plant extracts on root-knot nematode. Int. Network Newsl. 6(2): 31 – 32.
- Sultana, S., Khokon, M.A.R., Ahmad. M.U. Hannan, M.A. and Islam, K.M.N. 2006. Efficacy of BAU-Biofungicide and BINA-Biofertilizer in controlling roo-knot of soybean. Bangladesh J. Crop Sci. 17(1): 93-96.
- Timm, R. W. and Ameen, M. 1960. Nematodes associated with commercial crop in East Pakistan Agric. Pak. 11(3) : 355-366.
- Trivedi, P. C.; Bhathnagar, A. and Tiagi, B. 1978. Tests for chemical control of *Meloidogyne incognita* on watermelom. Nematol. Medit. 6 (1): 129-132
- Tverdyukev, A. P., Nikonovand, P. V. and Yuschenko, N. P. 1994. *Trichoderma*. Rev. Pl. Pathol. 73(4): 237.
- Vyas, R. V. and Patel, D. J. 2001. Management of root-knot nematode in banana. Indian J. Nematol. 31(1): 86-87.
- Yang-Xiu Juan, He-YuXian, Chen-Furu and ZhengLiang, 2000. Isolation and selection of eggmass of *Meloidogyne* spp. in Fujiana province. Fujiana J. of Agril. Sci. 15(1): 12-15.

Zahid, M. I., Hossain, M. S. and IBN-I Hasan, O. 1992. Nematicides to control root-knot of brinjal, Bangladesh. J. Plant Pathol. 8(1&2) : 31-33.

Zaiyd, M. 1977. Effect of organic soil amendments on the incidence of root-knot-nematode (*Meloidogyne javanica*) on bhindi plants. Proceedings of the Bihar Aca. Agril. Sci. 25 (1):23-26.

Zaki, F. A. and Bhatti D.S. 1989. Phytotherapeutic effect of some plant leaves on *M. javanica* infecting tomato plants. Nematol.Mediterr. 17 (2): 71-72.