MANAGEMENT OF ROOT-KNOT DISEASE OF BRINJAL CAUSED BY *Meloidogyne* spp.

By –

A THESIS
BY
REGISTRATION NO. 26154/00451
MASTER OF SCIENCE
IN
PLANT PATHOLOGY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY
SHER-E-BANGLA NAGAR, DHAKA-1207
BANGLADESH

DECEMBER-2006

MANAGEMENT OF ROOT-KNOT DISEASE OF BRINJAL CAUSED BY *Meloidogyne* spp.

By

BY

REGISTRATION NO. 26154/00451

A thesis
Submitted to the faculty of Agriculture,
Sher-E -Bangla Agricultural University, Dhaka,
In partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE
IN
PLANT PATHOLOGY
SEMESTER: DECEMBER 2006

Approved by:

Mrs. N. Akhtar.
Mrs. Nasim Akhtar
Professor
Department of Plant Pathology
Sher-e-Bangla Agricultural University
Supervisor

Kishwar Sultana
Kishwar Sultana
Principal Scientific Officer
Pest Management Division
Bangladesh Jute Research Institute
Co - Supervisor

(Dr. Md. Rafiqul Islam)
Chairman
Examination Committee

CERTIFICATE

This is to certify that the thesis entitled "MANAGEMENT OF ROOT-KNOT DISEASE OF BRINJAL CAUSED BY *Meloidogyne* spp" submitted to the faculty of Agriulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirement for the degree of MASTER OF SCIENCE in PLANT PATHOLOGY, embodies the result of a piece of bonafide research work carried out by, Anjuman Ara, Registration No. 26154/00451, under my supervision and guidance. No part of this thesis has been submitted for any other degree in any other institutions.

I further certify that any help or sources of information, received during the course of this investigation have been duly acknowledged.

Mrs. N. Akhtar

Dated:
Dhaka, Bangladesh

Mrs. Nasim Akhtar
Professor
Department of Plant Pathology
Sher-e-Bangla Agricultural University
Supervisor

ACKNOWLEDGEMENT

All praises to almighty 'Allah' who enabled the author to carried out the research work and writing up the thesis leading to Master of Science (MS) in Plant Pathology.

The author expresses her grateful respect and wishes to her whole hearted gratitude and appreciation to her benevoled teacher and supervisor Mrs. Nasim Akhtar, Professor, Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka for her invaluable suggestions, constructed criticism, proper guidance and helpful comments through out the study. She actually initiated the author to undertake such a study, of new dimension and took keen interest and intellectually guided the author to develop the conceptual frame work of her research study. She tooks much pain to edit the thesis and offered valuable suggestion for improvement. Her scholastic supervision and constant inspiration brought this thesis up to its present standard.

The author expresses her deepest sense of gratitiude, indebtedness and sincere appreciation to her co-supervisor Kishwar Sultana, Principal Scientific Officer, Pest Management Division, Bangladesh Jute Research Institute, Dhaka for her invaluable advice, constant inspiration and helpful suggestions.

The author also expresses her cordial thanks and gratefulness to all other respected teacher of Department of Plant Pathology, Sher-e-Bangla Agricultural University, for their valuable advice, suggestions and constructive criticism.

The author is grateful to laboratory and office staffs of the Department of Plant Pathology and Farm Division of SAU, for their co-operation, carefulness, encouragement and help to complete research work.

The author also convey her special thanks to Md. Abu Sadat, Md. Noman Faruq and late Parvez Rana for their ingerious help to analyze data, and for taking photographs of research work.

In final, the author is highly indebted to her beloved parents, brother, husband and sister for their sacrifices and inspirations in all phases of this academic pursuit from beginning to the completion.

The Author

MANAGEMENT OF ROOT-KNOT DISEASE OF BRINJAL CAUSED BY *Meloidogyne* spp.

ABSTRACT

A field experiment was conducted for the management of root-knot of brinjal with nematicides Furadan 5G (@ 12g/plot), neem product neembicidin (@ 5 ml/L water), and organic soil amendment poultry refuse (@ 2 kg/plot) either singly or in different combination. It was observed that application of the treatments neembicidin, poultry refuse and combination of Furadan 5G combined with poultry refuse reduced root-knot nematods population, gall index and improved plant growth of brinjal. Among the treatments poultry refuse combined with Furadan 5G appeared to be the best. Neembicidin and poultry refuse individually did not cause satisfactory improvement of plant growth. Significantly higher yield (1.5 t/ha) was found under the treatment T_4 (Furadan and poultry refuse). But the treatment T_4 resulted statistically similar effect to that of treatment T_7 (Furadan 5G, poultry refuse, neembicidin) in reducing gall and increasing yield of brinjal over control. By correlation and regression study it has been found that the galling incidence hampered the crop growth in terms of shoot and root length along with fresh and dry root weight.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOGRAPH

LIST OF APPENDICES

INTRODUCTION

Brinjal or Eggplant *(Solanum melongena)* is one of the most common popular vegetables grown in Bangladesh and other parts of the world. It belongs to the family Solanaceae. It grows almost all the year round but yield is much during winter. The brinjal is of much importance in the warm areas of far east, and grown extensively in Bangladesh, India, Pakistan, China and Philippines. It is also popular in France, Italy and the United states.

Brinjal is locally known as "Begoon" and its early name is Aubergine or eggplant. It also known as Guinea squash and garden egg (Nonnecke, 1989). It is thought to be originated in Indian sub-continent because of maximum genetic diversity and closely related species of Solanum are grown in this region (Rashid, 1976; Zeven and Zhukovesky, 1975).

In Bangladesh, it is being consumed as a cooked vegetable in various ways. There are several varieties of brinjal grown in our country, Such as kazla, Zhumka, Nayantara, Islampuri, uttara, Luffa (elongated), Luffa (black), Luffa (White), Luffa (BAU), Luffa (oblong), Bholanath, Dohajari, ISD-006, China, EG-190, Dhundul etc. All the varieties are not high yielding, Some high yielding varieties in our country are, BARI Begun-2 (Tarapuri), BARI Begun-4 (Kajla), BARI Begun- 5 (Nayantara).

It is largely cultivated in almost all district of Bangladesh. It can be grown at homestead area and kitchen garden because of its popularity especially for urban people. About eight million farm families are involved in egg plant cultivation (Islam, 2005). This gives small, marginal and landless farmers a continuous source of income and provides employment facilities for the rural people. For most of the time, except peak production period, market price of eggplant compared to other vegetables remain high which is in favour of the farmer's slovency. So, it plays a vital role to boost our national economy.

Brinjal plant is the second most important vegetable crop next to potato in Bangladesh in respect of acreage and production (BBS, 2005). The total area of eggplant cultivation is 60100 hectare where 22500 ha in kharif season and 37500 ha in Rabi season with total annual production of 358400 mt. and the average yield is 6.0 t/ha in 2003-04 year (BBS, 2005). It is grown round the year both as winter (Rabi) and summer (kharif) crops (Rashid, 1993).

Of many reason for high price of eggplant, lower production rate is important. Incidence of insect pests and diseases greatly hampered the production of brinjal plant. Brinjal has various types of disease caused by fungi, bacteria, viruses, mycoplasma and nematodes. Among the fungal diseases, most important is blight, damping off, alternaria leaf spot, cercospra leaf spot, caused by *Phomopsis Vexans, Pythium spp. Alternaria Melongenae* and *Cercospora melongenae* respectively. Little leaf caused by mycoplasma, mosaic caused by viruses and the both root-knot nematode *Meloidogyne javanica* and *Meloidogyne incognita also* attack in brinjal and caused root-knot disease.

In Bangladesh root-knot may cause as much as 27.2% loss in fruit yield of eggplant (BARI, 2001). In India brinjal production was reduced by 27% due to attack of root knot nematodes under field condition. Estimation of cropIoss in the tropics due to root-knot nematodes ranged from 17-20% on brinjal plant, 18-33% on melon and 24-38% on tomato (Subarshan and chakraborty., 2001)

The seconds stage larvae of nematode penetrate in to young roots of host plant and induced the development of various size and number of galls, where they can feed and reproduce easily. The vascular tissues are damaged by young larvae and cause impairment of the nutrient and water uptake from the soil. They cause appreciable yield loss of the crops (Rahman *et al.*,1990)

Root-knot disease can be controlled by using nematicides. The primary advantages of nematicidal control than other methods is that the nematode population in soil is reduced to a very low density within a short period after application. Carbofuran, is commonly used as granular nematicide. It is available in Bangladesh under different trade names. Furadan 5G (Carbofuran) has been reported to be effective to control root-knot nematodes and to increase growth and yield of various crops. But large scale use to chemical nematicides is not be feasible under Bangladesh condition due to their scarcity, high cost, hazardous in use, difficult to spray on small fields and risk of environmental pollution.

Physical, cultural and biological, approaches are found to be effective to control *Meloidogyne* spp. and to increase plant growth. In physical method hot water treatment, soil solarization and elimination of weeds and roots of diseased crops can be used to control this disease (Zhang 1987). Crop rotation, fallowing, deep ploughing and use of resistant varieties are the useful cultural methods against root-knot nematodes. Now a day's biological control method and integration of different cultural methods are being used as effective control measures against nematodes, to avoid or reduce the use of chemical nematicides (Mohanty *et al.* 2003, Sudarshan and Chakrabonty, 2001).

In the present socio-economic situation of Bangladesh cultural practices like organic amendments to soil are considered as the cheapest method for nematode control. Various types of low cost organic amendments including poultry refuse (Chicken manures), cow dung, farm yard manure (FYM), saw dust, different oil cakes, and leaf extracts of neem (Nanjegowda *et al.* 1985, Alam *et al.* 1980) have been reported to be effective in controlling root-knot nematodes (Singh and sitaramaiah 1973, Miah and Rodriguez- Kabana 1982. Control through organic amendments of soil is increasing day by day and gaining popularity for soil born pathogens.

Recently Integrated Pest Management (IPM) approach is gaining popularity. Where various management (such as host resistance, cultural control, chemical control and biological control) approaches are followed in integrated way to ensure eco-friendly condition. Though the use of resistant varieties are cheap, easy to use and non hazardous, production of host resistant has not yet become as available method because of frequent failure of resistance in the host and formation of new virulent strain or races or biotypes among the pathogen (Gaur and Gaur 2003).

To grow brinjal successfully and profitably nematode problems should be properly addressed. This will help to increase brinjal yield and farmer's income. Under the scenario discussed above, to identify the components for management of Root-knot of brinjal plant is an urgent demand. But there exists a few evidence of research work for management of root-knot disease of brinjal plant in Bangladesh. Hence this experiment has been designed to achieve the following objective:-

1. To find out comparative efficacy of Furadan 5G, and Neembicidin either alone or in combination with oragnic amendments in controlling root knot disease of brinjal.

REVIEW OF LITERATURE

Root knot is a major nemic disease not only in Bangladesh but also in other countries of the world like Srilanka, Philippines, Pakistan, India and where ever brinjals are produced. This disease is caused by nematodes of *Meloidogyne* spp. Also some other nemtodes like *Pratylenchus* spp, *Helicotyenchus* spp, are associated with root of brinjal. Many researches have been conducted to control this nemic disease with nematicides, Furadan 5G and with organic amendments in many countries of the world. Some of the works pertinent to the present studies have been reviewed in this chapter.

2.1 Symptoms of Root-Knot disease of brinjal plant

Root-knot caused by *Meloidogyne incognita* is important and widely distributed disease in the country (Talukder, 1974, Ahmed and Hossain, 1985 and Mian, 1986). The nematodes are soil borne roundworms that attack the root system of brinjal plant.

Agrios (2000) reported that characteristics symptoms of the disease appear on the underground parts of the plants. Infected root swell at the point of invasion and develop in to the typical root-knot galls that are two to several times as large in diameter as the healthy root. Several infection take place along the same root, and the developing galls give the root a rough, clubbed appearance. Roots infected by certain species of the nematode develop in addition to galls, several short root branches that rise form the upper part of the gall and result in a dense, bushy root system.

Mian (1994) reported that due to attack of root-knot nematodes, the cell walls closest to the nematodes head become increased in size, or hypertrophic. The abnormally large cells induced by root-knot nematodes (*Meloidogyne* spp.) during feeding are examples of hypertrophic cells. Hyperplasia, an increase in cells number, is also generated by root-knot nematodes. Infected roots with hyperplastic tissue have bulbous swelling and appear distorted. *Nacobbus* spp. can also produce root galls.

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

The soil and climatic condition of Bangladesh has made her an ideal abode for nematodes. A preliminary survey found 15 genera of plant parasitic nematodes associated with commercial drops in Bangladesh Where root-Knot nematode *Meloidogyne* is the most abundant and widespread (Timm and Ameen, 1960 and Ahmad, 1977) Moreover, the nematode population in the soils of Bangladesh is increasing day by day (Chowdhury, 1976). In Bangladesh, root-knot disease ranks as one of the most important disease of nematode caused by *Meloidogyne incognita* and *Meloidogyne javanica*. They attack wide variety of field, fruit and vegetable crop including brinjal (Biswas. 1979). In certain crops, the loss is increased because root-knot predisposes the plants to injure by other disease (Chester, 1950).

2.2 Pathogenic description of *Meloidogyne* spp.

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

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

2.3. MANAGEMENT OF ROOT-KNOT DISEASE

2.3.1. Management through Furadan 5G (Carbofuran)

Furadan 3G is highily effective nematicide owing to its rapid dispersal in soil and its systemic action when taken up by plants and most effective in controlling *Meloidogyne* spp. (Homeyer, 1973; Yaringano and Villalba 1977).

Hossain *et al.* (2003) conducted an experiment to determine the efficacy of pre plant soil treatment with a nematicide and organic amendments to the soil for the management of root-knot nematodes *(Meloidogyne* spp.) of brinjal plant in Jamalpur. Among the treatments, Fradan 5G supplemented with poultry refuse gave the best result in reducing root-knot disease and to improve plant growth and fruit and fruit yield of brinjal plant.

Singh *et al.* (2001) the efficacy of neem cake and/or Carbofuran for management of disease complex caused by *Fusarium oxysporum* and *Meloidogyne incognita* on cowpea and found that application of both neem cake and carbofuran, in general, significantly increased plant growth and reduced nematode multiplication.

Nanjegowda *et al.* (1998) studied the efficacy on various neem products and a nematicide (Carbofuran) against *Meloidogyne incognita* in a tomato nursery. All the neem products and Carbofuran significantly reduced the nematode population and increased yield. However, Carbofuran was found to be more effective in reducing root gall and increasing plant growth, followed by neem kernel neem cake and neembicidine.

Devappa *et al.* (1997) observed the effect of carbofuran at 2 kg a. i. /ha, neem cake at 12.5 t/ha either singly or in combination, for the management of *Meloidogyne incognita* infecting sunflower, under the field condition. A combination of Carbofuran and neem cake increase the plant growth characters like shoot height, shoot weight, root length, root weight and grain yield, and reduced the nematode population in soil and root galling.

Enokpa *et al.* (1996) investigated the effect of Furadan 3G (Carbofuran) on the control of *Meloidogyne incognita* with 3 concentrations of Carbofuran (12.35, 24.7, and 49.4 kg a.i. /ha), the best vegetative growth occurred with 24.7 kg a.i./ha. There was a significant difference in the plant dry weight and galling incidence at the different treatment levels.

Hasan (1995) carried out research with Furadan 5G and Miral 3G tested against root-knot of brinjal in granular and liquid forms of application, either alone or in combination. The two chemicals on higher concentration in both types application gave superior response in plant growth characters with corresponding lower number of galls, adult females and egg masses. Larval population was more suppressed by Furadan 5G.

Zaki and Maqbool (1995) showed in a field experiment that the nematicide, Furadan significantly reduced *Meloidogyne* spp. infection in tomato.

Zahid *et al.* (1992) observed that Basamid @ 300, 400, and 500 kg, Sunfuran 30, 40, and 50 kg, Smite 50, 75, and 100 kg and Furadan 5G 30 kg/ha were effective in reducing the severity of the root-knot disease of brinjal, producing reduced number of galls, larvae and females in roots. They also found that sunfuran 3G @ 50 kg/ha appeared to be best in reducing the severity of root gall and improving plant growth.

Mian *et al.* (1991) reported control of root-knot diseases (*Meloidogyne incognita)* in potato *(Solanum tuberosum)* with furadan 3G. They observed enhanced plant growth and decreased development of nematode and severity of root-knot. They also observed that better plant growth and nematode control corresponded to the higher rate of chemical applied to the soil ranging from 1.0 to 2.5 kg soil.

Bhagawati and Phukar (1990) tested four chemicals viz. Carbofuran, Diazinon, Ekalux and phorate each @ 1, 2 and 3% (w/w) as treatment for the control of *Meloidogyne incognita* infecting pea under laboratory and field conditions. All the chemicals were effective even at lower application in reducing gall and egg masses in the roots of pea and increased yield. The best result was found with carbofuran at 3% level.

Gupta and Sharma (1988) found Carbofuran as the most effective chemical nematicides in reducing the average number of galls on papaya plant. Plant height and weight were also improved by the treatment.

Ahmed and Bhuiyan (1987) tested Furadan 3G against root-knot disease of brinjal and found that the chemicals most effective when applied at 0.1 g/hole during transplantation.

Haq and Saxena (1986) compared foliar sprays, soil drench and root dip application of Carbofuran 3G @ 500, 100, 50, and 10 ppm concentration in reducing population of *Meloidogyne incognita* and improving plant growth in tomato seedling. Root dip treatment with 100 and 500 ppm of Carbofuran gave effective control as did foliar spray with 500 ppm.

Maqbool *et al.* (1985) showed that Aldicarb or Carbofuran were effective in controlling *Meloidogyne incognita* in cauliflowers. Aldicarb at 2 kg/ha gave nearly complete control of the nematode and caused increased plant growth up to 47%

Naganathan (1984) found that pre plant application of Metham sodium, Carbofuran or Aldicarb reduced the root galling of tomato plants infested with *Meloidogyne incognita*

Gichure and Ondieki (1984) applied Aldicarb, Phenamiphos, Carbofuran or Dazamet to potato field infested with *Meloidogyne incognita* and found that Phenamiphos was the most effective nematicide in reducing *Meloidogyne* population and increased yield follwed by Dazamet, Carbfuran and Ethoprop.

Rana and Gupta (1981) observed reduction in root galling and increase in growth of chickpea as a consequence of pre plant application of Carbofuran at the rate of 1.5 and 3.0 kg/ha to soil infested with *Meloidogyne javanica.*

Katalon-Gateva *et al.* (1979) reported that the application of Furadan 10G (Carbofuran) granuler at kg/1000 m^2 twice (once before and once after planting tobacco) or once at 10 kg/100 m^2 (before planting), grately reduced the number of nematodes (adult and larvae) in the soil. In tobacco roots, Carbofuran greatly reduced the number of *Meloidogyne incognita* in the soil and in the roots and inhibited gall formation with efficacy index of 74-78%.

2.3.2. Neem product to control root knot nematode:

Zarina et al. (2003) reported that Neem leaf extract showed better result followed by *Calotropis procera*, and *Datura fastuosa* at a higher concentration giving maximum plant height, number of leaves fresh and dry weight of shoot and significantly suppressed the root galls and egg masses per plant on brinjal in Pakistan.

Prakash *et al.* (2002) showed that Nimin (a product of Neem) was the most beneficial treatment followed by oil of Neem, castor, and rocked salad on the growth of okra. Higher doses were more effective than the lower doses. The growth, dry weight and chlorophyll content of okra plant also improved.

Sharma *et al.* (2000) reported significant reduction in the number of galls with soaking of okra seeds of in 5% Neemark and Neembicidin for 6 and 24 hours. Plant growth improved with the increase in the concentration of Neemark and Neembicidin.

Hossain *et al.* (1999) reported that organic soil amendment with leaves of *Chrysanthemum* sp., *Azadirachta indica, Tagetes* sp. as well as sesame oil, neem oil and coconut oil cake significantly reduced the root knot severity and increase the length and weight of shoots and roots and the growth of rice seedlings.

Akter and Mahamood (1996) reported that populations of plant parasitic nematodes on potato were significantly suppressed when the soil was treated with oilcakes or leaves of neem (*Azadirachta indica*) and castor (*Ricinus communis).*

Darekar et al. (1990) tested the effect of neem (*Azadirachta indica)* Karanji (*Pongamia glabra),* Mahua *(Madhuca indica) and Castor (Ricinus communis*) oil cakes in a field experiment on control of *Meloidgyne incognita* of tomato. All treatments at 400 kg/ha reduced *Meloidogyne incognita* population and gall index, with neem and karjan cake being the most effective.

Chhabra *et al.* (1988) reported that the leaf extract of *Ricinus conmmunis,. Leucaen leucocephala, Populus deltoides, Azadirachta indica, lantana camara* and *Eucalyptus hybride* were highly toxic to j2 of *Meloidogyne incognita.* Among these , leaf extract of *Richinus communis* was found to be the most toxic to *Meloidogyne incognita.*

Lee (1987) found that leaf and seed extract of *Melia azadirachta* inhibited the hatching of root-knot nematode, *Meloidogyne incognita* and killed the larvae in four months old *Paulownia taiwaniana* saplings and resulted greater height and fewer root-knots.

Siddique and Alam (1987) reported that water soluble extract of *Azadirachta indica* and *Melia azedarach* were effective against *Meloidogyne incognita* or *Rotylenchus reniformis* population in seedlings of tomato and okra.

Nanjegowda *et al.* (1985) reported that neem (*Azadirachta indica*) oil cake at 2 kg/m was the most effective treatment in increasing the germination of tobacco seedling and reducing the number of root-knot infested seedling and gall/ plant.

Bora and Phukan (1983) tested 4 soil amendments (musterd oil cake, poultry manure, sawdust and decaffeinated tea waste) that gave significant reduction of *Meloidogyne incognita* populations on jute. Sawdust was more effective than tea waste and poultry manure at the lowest dose was the least effective. Sawdust and to lesser extent tea waste, had the best effective on plant height and the dry and wet weights of shoots and roots.

Mian and Rodriguez-kabana (1982) studied about the nematicidal efficacy of the soil amendments. Amendments with material having C/N ratios in the ranges of 15-20 were the most efficacious against the nematode when all the amendments were applied at 1.0%.

Zaiyd (1977) showed that Neem leaves (*Azadirachta indica*) gave some control against root-knot disease of okra caused by *Meloidogyne javanica.*

Siddiqui *et al.* (1976) reported that oil cakes of neem (*Azadirachta indica*), groundnut (*Arachis hypogaea*), mustard (*Brassica campestris*), castor (*Ricinus communis*) and mahua (*Madhuca indica*) gave effective result in controlling nematode populations and increasing yields if several vegetables such as sugar beet, radish, and turnip.

2.3.3. Management through organic amendments

To control soil borne disease of crops with organic amends are relatively a recent and ecofriendly innovation. Some important literature related to the organic amendments of soil to the control soil borne disease especially of root-knot disease caused by *Meloidogyne* spp. are reviewed in this chapter.

El-Nagdi *et al.* (2003) reported that soil amended with composted and non composted sugarcane residue showed significant reduction in the number of galls and egg masses of *Meloidogyne incognita* causal agent of root knot disease of okra cv. Baladi Plant growth parameters also increased compared to untreated the control.

Rhaman *et al.* (2001) stated that, soil amendments, such as incorporation of poultry refuse, mustard-oilcake, neem-oil cake and burning of sawdust were highly effective in controlling soil-borne pathogens in vegetables seedbeds and in main planting fields. These practices reduced the disease include plant mortalities, enhanced plant growth and yields and brought higher economic returns to the farmers. Among the treatments, the use of poultry refuse and mustard -oil cakes showed best results.

Fatema and Sweelam (2001) tested the efficacy of different organic manures such as Farmyard Manure (FYM), chicken and pigeon manures and potassium feritlizer on the growth, dry matter yield and nutrient uptake of faba bean cv. Giza 20 under root-knot *Meloidogyne javanica* infestation in pot experiment. They found that chicken and pigeon manures were the most effective among the organic sources in improving different plant growth parameters and suppressing nematodes.

Marull *et al.* (1997) reported that soil amendment with olive (*Olea europeae*) oil cake, chicken litter, and municipal compost gave signifcant control of *Meloidogyne javanica* in green pepper (*Capsicum annum*) under greenhouse condition. They also found that plants in soil amended with the materials had lower numbers of *Meloidogyne javanica.*

Five organic amendments viz. marigold, poultry refuse, pigeon refuse, mixed applicaton of poultry and pigeon refuse and mustard oil-cake were tested against root-knot nematode by Nahar *et al.* (1996) They found that all caused reduction of root-knot severity and improved growth of tomato plants. They also observed that mixed application of poultry and pigeon refuse gave the best result follwed by poultry refuse, mustard oilcake, pigeon refuse and marigold.

The effect of poultry manure on *Meloidogyne* spp. in tomato was investigated by Wahundeniya (1991) and he found that application of high rates of poultry manure (10 ton/ha) reduced root-knot nematode population considerably in infested soil.

Ali and Mian (1989) found that amendment of soil with oil cake of cotton and mustard gave significant control of root knot of potato and increased plant growth of potato.

Pathak *et al.* (1988) reported that, fresh, chooped, dried and ground leaves and plant parts and compost of water hyacinth (*Eicchornia crassipes*) and dried and ground neem leaves at 30 q/ha were added to pots of brinjal plant infested with *Meloidogyne incognita*. All treatment significantly decreased number of galls and egg masses.

Mesfin *et al.* (1987) conducted a factorial experiment to determine the effective of five control strategies in controlling *Meloidogyne incognita* in kenaf. The control strategies used were the application of poultry refuse (5 t/ha), sawdust (5 t/ha), neemcake (294 kg/ha). All the strategies reduced root-knot nematode population, eggmass number per root and root galling based on the comparison with control.

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

Mian and Rodriguez-Kabana (1982) investigated the effect of soil amendments with oil cake and chicken litter for the control of *Meloidogyne arenaria* in green house experiment with squash (*Cucurbita pepo L.*) and found that, the amendments reduced galling caused by nematode and stimulated plant growth.

Mahamood *et al.* (1982) reported that amending soil with different concentration of leaf and seed extracts of various indigenous medicinal plants showed increased mortality of *Rotylenchus reniformis* and *Meloidogyne incognita*. The mortality rate increased with the increase of the extract and exposure period.

D. errico and Maio (1980) reported that addition of dried poultry refuse, dried poultry manure, and composted oilcake, municipal refuse and partially composted poultry manure to field significantly reduced infestation of *Meloidogyne incognita* in tomato.

Srivastova *et al.* (1972) conducted a test with oilcakes of neem, castor, linseed, musterd groundnut, sawdust and mahua organic amendments to the soil to determine their efficacy against *Meloidogyne javanica* on tomato and brinjal. It was found that sawdust @ 10880.44 kg/acre and neem cake @ 486 kg/acre showed maximum efficacy in reducing the gall formation the root.

Hameed (1970) indicated that mustard oil cake was effective than other oil cake in reducing population of *Meloidogyne incognita* in tomato.

Singh and Sitaramaiah (1966) obtained reduction in the incidence of root-knot nematodes in tomato and okra by soil amendment with leaves of karanj, margoṣa, *Melia azadirachta* L.,*C. occidentalis* L., crotalaria (*Crotalaria juncea* L.*)*, and *Sesbania aculeata* Pers.

MATERIALS AND METHODS

3.1 Experimental site:

The experiment was conducted in the field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207.

3.2 Experimental period:

The experiment was conducted during the period from December 2005 to April 2006.

3.3.1 Soil type

The soil of the experimental plot was loam to clay loam in texture belonging to the Madhupur Tract (AEZ-28). The description of the Agro-Ecological Zone (UNDP and FAO, 1988) of the experimemtal site is sited below:-

Agro Ecological Region	: Madhupur Tract (AEZ- 28).
Land type	: Medium high land.
General soil type	: Non- Calcareous Dark gray floodplain soil
Soil series	: Tejgaon
Topography	: Up land
Elevation	: 8.45
Location	: SAU Farm, Dhaka.
Field level	: Above flood level.
Drainage	: Fairly good.
Firmness (consistency)	: Compact to friable when dry.

The physical and chemical characteristics of the soil collected from Soil Resource Development Institute (SRDI), Farmgate, Dhaka and is presented below (For 0-14 cm depth):-

Particle size distribution:

Sand	: 34%
Silt	: 46%
Clay	: 20%
Soil texure	: Loam to clay loam.

3.4 Pre- soil test

Pre-soil test was done to ensure the presence of nematodes in the experimental plot before sowing seedling in the plot. For this purpose Bangladeshi plate method (Photo-4,5,6) was used.

3.5 Climate

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

3.6 Weather

The monthly mean of daily maximum, minimum and average temperature, relative humidity, monthly total rainfall and sunshine hours received at the experimental site during the period of the study have been collected from the surface synoptic Data card, Bangladesh Meteorological Department, Sher-e-Bangla Nagar, Dhaka and Shown in appendix 2.

3.7 Variety used

Eggplant variety luffa was used for the experiment.

3.8 Collection of seedling

Healthy, matured and disease free seedling of luffa varity were collected from local market, Gazipur on 19th December. Two hundred seedlings were collected.

3.9 Treatments of the experiment

In this study eight treatments were used as designated by T_1, T_2, T_3, T_4, T_5, T_6, T_7 and T_8, which were as follows :-

T_1 = Furadan 5G @ 60 kg/ha (12 g/plot)

T_2= Poultry Refuse @ 10 ton/ha (2 kg/plot)

T_3 = Neembicidin @ 5ml/L water

T_4 = Furadan 5G+ Poultry refuse

T_5 = Furadan 5G+ Neembicidin

T_6 = Poultry refuse + Neembicidin

T_7 = Furadan 5G + Poultry refuse + Neembicidin

T_8 = Control

3.10 Collection of test materials

Furadan 5G, Neembicidin were purchased from the market. Poultry refuse was collected from the Poultry Farm.

3.11 Land preparation

The land was firstly ploughed with a power tiller and prepared using well decomposed cow dung and poultry refuse in the first week of December 2005 and left exposed to sunlight for 7 days. Then the land was ploughed and cross ploughed by a country plough until the soil had a good tilth. It required six times ploughing and every ploughing was followed by laddering to level the land and break up clods. The soil was also pulverized by several spading. After each ploughing weeds and rubbish were removed to obtain desirable tilth. Finally spade (kodal) was used to prepare plots and drains. The requisite quantities of poultry refuse @ 10 ton/ha, or 2 kg/plot was added to the field and allowed to decompose for two weeks, to avoid phytotoxicity to the brinjal seedling. The plots were ready for seedling transformation after 14 days of poultry refuse application.

3.12 Application of the poultry refuse

Application of low cost organic amendments including poultry refuse (Chicken manure) (Photo-1), was mixed to the soil to increase the number of fungus feeding, bacteria feeding, omnivores and predatory and decrease the number of plant-parasitic nematodes. The process of decomposition produce sufficient heat to kill the nematodes and the decomposition products of the manures are directly toxic to the pests. Moreover, amendments cause an increase in their natural enemies like fungi, bacteria and predaceous nematodes.

3.13 Application of Manure and Fertilizers

Manure and fertilizers were applied as per standard recommendation. The following doses were used for carrying out the field study (Anonymous, 1997).

Fertilizers and manures used in the experimental field

Fertilizers and manures	Rate (kg/ha)
Urea	175.00 (35 g/plot)
TSP	125.00 (14 g/plot)
MP	150.00 (16 g/plot)
Cowdung	10000.00 (4 kg/plot)

A half of the total amount of cow dung and TSP were applied during final land preparation and remaining half was applied in the pits before transplanting. Urea and MP were applied in two installments as ring dressing after 15 and 35 days of transplanting.

3.14 Design and Layout of the experiment

The experiment was carried out in Randomized Complete Block Design (RCBD) with three replications. The whole plot was divided into three blocks, Then each blok was divided into eight plots and the total plot was altogether 24 unit plots (Appendix-0). The space kept between the blocks was 1m wide and between plots it was 0.5m. Plant to plant distance was maintained 75cm respectively and each unit plot contained eight plants for each treatment.

3.15 Application of neembicidin :

Neembicidin is a commercial product of neem seed extract, markte by pesticide company ACI, Bangladesh,were applied @ 5 ml/lit water Neembicidin was mixed with the water and applied twice to the field soil. First during transplantation of the seedling and 2nd dose was applied eight week after transplanting of the seedling.

3.16 Application of Furadan 5G in soil

Furadan 5G was applied twice during the experimental period. First dose was applied after transplanting of 7 days and second dose was applied after 75 days of transplantation. The detailed specification of Furadan 5G is given below:-

Specification of Furadan

Common name (Trade name)	Chemical name	Active ingredient	Mode of action
Furadan 5G	Carbamic acid, methyl-2,3-dihydro-2,2-dimethyl-7-benzofuranyl ester	Carbofurn	Systemic(Reversible binding of acetylcholin esterase,esterase, pharmacologic actions)

(Rashid, 2000)

3.17 Transplanting of seedling

After preparation of main field 21 days old seedling were transplanted in the experimental plots on the 20th December 2005. A sufficient irrigation was given just after transplantation with the help of a bucket sprinkler. For keeping seedlings upright, support with bamboo sticks were provided. One seedling was placed in a pit. The transplanted seedling were protected from the sunlight, shading with banana leaf sheath cuttings (photo-4). Shading and watering was continued till the seedlings were established in the field.

3.18 Intercultural operations

3.18.1 Gap filling

After trarsplantation gap filling was done in case any seedling died.

3.18.2 Weeding

Weeds growing out in the plot during the growing period of the bringal. First weeding was done at 25 days after transplantation.

3.18.3 Irrigation

After weeding and fertilizer application flood irrigation was given (in case of second split) by filling the drains surrounding the beds by pumping water in those drains with a water pump .

3.18.4 Drainage

After soaking the plots excess water was allowed to be drained out.

3.18.5 Others

The plants were observed regularly. General field sanitation was maintained throughout the growing period by removing infected and blighted leaves wilted and dead plants. Insects were controlled as and when necessary by spraying insecticides named Aaktara and Malathion @ 0.2%.

3.19 Harvesting

The crop was harvested on 27 th March 2006 at full ripening stage. The eight plants of each plot were harvested seperately. The fruits are usually cut from the vines since the stems are hard and woody. The large calyx and a short piece of the stem are left on the fruit, but care should be taken to prevent the stem from injuring other fruits in the package.

3.20 Collection of data :

At the end of the growing period the plant were uprooted from the field/plots. At first the soil of the plot was watered to make it moist and lose for easy uprooting. Uprooted plants were washed with running tap water to make the roots free from all dirt. Precaution was taken to minimize damage of root systems during uprooting and washing. Data on following plant growth and nematodes development characteristics were determined and recorded:

i) Shoot length (cm)

ii) Shoot weight (g)

iii) Root length (cm)

iv) Root weight (g)

v) Dry root weight (g)

vi) No. of galls/plant root

vii) Gall index (0-10)

viii) No. of nematode/plant root

ix) Yield (Ton/ha)

3.20.1 Shoot length (cm) and shoot weight (g)

Shoot length (cm) of each brinjal plant was determined by uprooting of the plant from the field. The brinjal were separated from the stem. Mesurement of the shoot height was taken from the top of the brinjal plant at the bottom. The shoot height of four plants of each treatment were taken and averaged. Separated shoot were collected and weighted in an electric balance.

3.20.2 Root length (cm) and fresh and dry root weight (g)

The roots were seperated from the brinjal plant, washed in tap water to remove the soil. Then each roots were randomly selected and total length of the each roots was determined. It was averaged to find out one root length. After than total root length was determined by counting the roots and multiplying. Separated roots were collected and weighted in an electric balance. Then fresh root were dried in the sun and also weighted in an electric balance.

3.20.3 Galls/plant root

For counting the galls/plant root, roots were randomly selected. Gall was counted by hand lens.

3.20.4 Gall index (0-10) scale

Gall index of five plants of each treatment was determined from randomly selected plant of each treatment. The root system were evaluated for degree of galling on a scale of 0-10, where 0 represented roots free from gall and 10 means having severe galling (Zeck, 1971)

3.20.5 Number of nematodes/plant root

The diseased plants roots were collected from the field and were taken to the laboratory, Data collection nematodes were isolated by Bangladeshi plate method (Modified white head and Hemming 1965) (Photo-7,8,9). Pear shaped female nematodes were observed under stereoscopic microscope.

Method of Extraction of nematodes from soil sample:

Materials:-

i) Extraction tray or bowl

ii) Nylon net supported on a plastic bowl

iii) Paper tissues and

iv) Soil sample

Methods :-

Cover the nylon net with a tissue .Carefully place the soil on tissue. Then placed the nylon net on the extraction tray. Water is added down the inside edge of the tray until the soil layer looks wet. The extraction tray is placed for 24-48 hours. After 24-48 hours nylon net (photo-7) must be removed carefully. The extraction water then poured into a beaker and were left to stand for 3-4 hours and allowing the nematodes to settle. Excess water then siphoned (photo-8) down to about 100mls. The suspension were thoroughly mixed by blowing in air bubbles through a pipette. 5ml of the thoroughly mixed suspension was pipetted is an open counting dish and examined under a stereoscopic microscopes, pear shaped female nematodes were observed (photo-9). Total plant parasitic nematodes were counted.

3.21 Analysis of Data

The data on length of shoot and root, weight of shoot and root, gall index, yield etc for each treatment was analyzed statistically to find out the level of significance. Treatment means were compared by DMRT (Duncan's Multiple Range Test). Correlation and Regression study was done to establish relation between shoot length, root weight with no. of gall among the treatments.

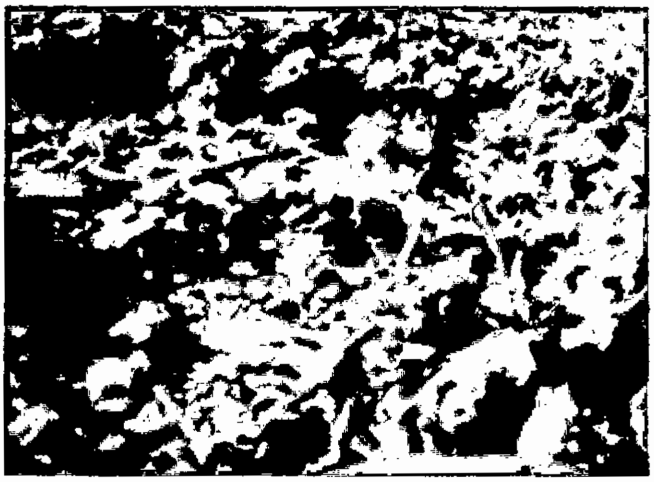


Photo 1 : Application of Poultry Refuse

Photo- 2 : Seedling of Egg Plant

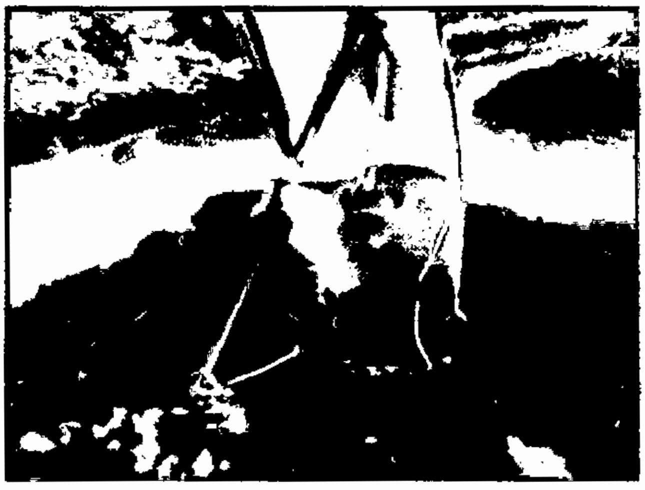


Photo- 3 : Shading of Egg Plant Seeding

Photo-4 : The Extraction tray is placed for 24-48 hours.

Photo-5 : Excess water was siphoned

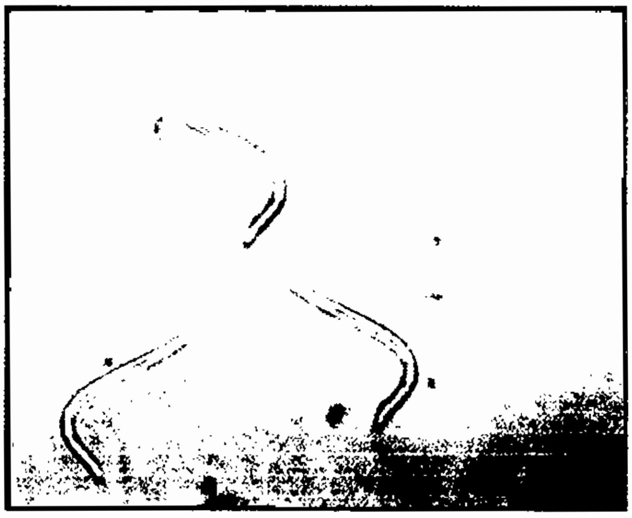


Photo- 6 : *Meloidogyne spp.* isolated from the infected soil

Photo- 7: The Extraction tray is placed for 24-48 hours.

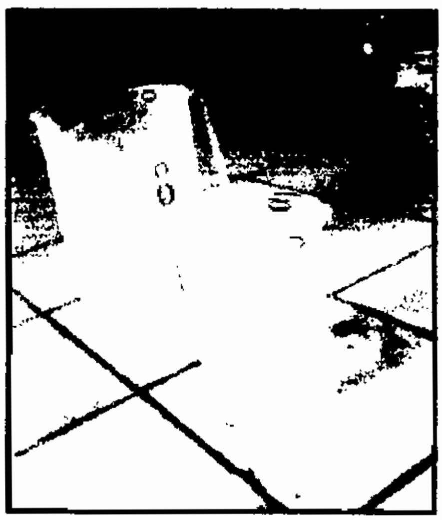


Photo- 8 : Excess water was siphoned

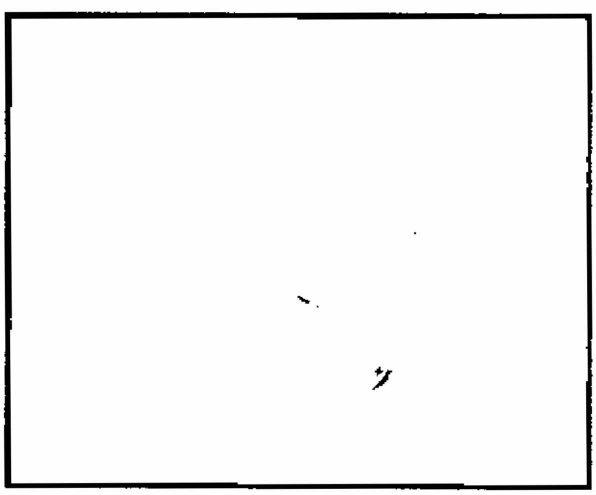


Photo- 9 : *Meloidogyne spp.* isolated from the gall of the infected root

RESULTS

4.1 Shoot length (cm).

From the Table 1. it was observed that the highest shoot length (81.08 cm) was recorded from the T_4, which received chemical nematicide Furadan 5G and poultry refuse. The second highest stem length (78.08 cm) was resulted from the treatment T_7, Where Furadan, poultry refuse and neembicidin were added. The third highest shoot length (75.92 cm) and (74.33 cm) resulted from the treat ment T_6, and T_5, Which received poultry Refuse + Neem pesticide, Furadan +Neembicidin, respetively. The shoot length of T_1 and T_2 was statistically similar. The lowest shoot length (68.75 cm) was resulted from the treatment T_3, which received only Neem pesticide. However, it was statistically similar with the treatment T_8 (control). Experimental plot showing three month old brinjal plant (Photo-10).

4.2 Shoot weight (g)

The highest shoot weight of a single plant (345.00 g) was obtained from the treatment T_4 followed by the treatments T_7(233.33g), T_6(225.00g) and T_5(224.58g/plant). The lowest shoot weight (172.08 g/plant) was resulted from T_8, preceded by T_3 (185.83 g), T_2 (197.50 g) and T_1 (191.25 g).

4.3 Root length (cm)

The highest length of a single root (28.93 cm) was obtained from the treatment T_4 followed by T_7 (22.43 cm) and T_6 (21.65 cm). Where the lowest root length (15.45 cm) was obtained under the treatment T_8 (control).

Table1. Effect of different treatments on plant growth characteristics against root knot nematode of eggplant

Treatments	Shoot length(cm)	Shoot weight (g)	Root length (cm)	Fresh root weight (g)	Dry root weight (g)
T_1	70.33 c	191.25 c	16.21 d	12.74 d	11.77 c
T_2	70.83 c	197.50 c	19.97 c	13.22 cd	12.23 cd
T_3	68.75 cd	185.83 c	16.39 d	12.47 d	11.58 c
T_4	81.08 a	345.00 a	28.93 a	23.62 a	22.18 a
T_5	74.33 b	224.58 b	20.21 bc	14.03 c	12.63 cd
T_6	75.92 b	225.00 b	21.65 b	14.56 c	13.08 c
T_7	78.08 ab	233.33 b	22.43 b	16.99 b	15.41 b
T_8	65.25 d	172.08 d	15.45 d	10.88 d	9.33 d
LSD	3.55	24.15	1.51	1.13	1.78
CV (%)	6.91	5.25	3.92	6.15	8.25

T_1 = Furadan 5G @ 60 kg/ha (12 gm/plot)

T_2 = Poultry Refuse @ 10 ton/ha (2kg/plot)

T_3 = Neembicidin @ 5ml/L water

T_4 = Furadan 5G+ Poultry refuse

T_5 = Furadan 5G+ Neembicidin

T_6 = Poultry refuse + Neembicidin

T_7 = Furadan 5G+ Poultry refuse + Neembicidin

T_8 = Control

Each value is an average of three replications. Means bearing same letter within the same column do not differ significantly at 5% by DMRT.

Photo- 10 : Experimental plot showing three months old brinjal plant.

4.4 Fresh root weight (g)

The highest fresh root weight of a single plant (23.62 g) was obtained from the treatment T_4 followed by the treatments T_7 (16.99 g), T_6 (14.56 g) and T_5 (14.03 g). The lowest root weight (10.88 g) was resulted from T_8 (control) preceded by T_2 (13.22 g), T_1 (12.74 g) and T_3 (12.47 g).

4.5 Dry root weight (g):

The highest dry root weight of a single plant (22. 18 g) was obtained from the treatment T_4 followed by the treatment T_7 (15.41g) , T_6 (13.08 g) and T_5 (12.63g). The lowest dry root weight (9.33g) was resulted from T_8 (control) preceded by T_2 (12.23 g), T_1 (1.77 g) and T_3 (11.58 g).

4.6 Number of nematodes / plant root:

The root-not nematode *(Meloidogyne* spp.*)* was isolated from brinjal plants and identified. From the Table-2 it was observed that all the treatments significantly reduced the number of root-not nematodes/plant root except the T_3 treatment, which received only Neembicidin. The highest reduction of nematodes (3.00/plant root) were achieved in the treatment T_4, where Furadan 5G and poultry refuse were added. The second highest suppression of number of nematodes/plant root was resulted from T_7 treatment, which received Furadan 5G+Poultry refuse+ Neembicidin. However, T_7 was statistically similar with that of T_5, T_6. The highest number of nematodes (7.33/plant root) was counted under the treatment T_8 (control).

Table 2. Effect of different treatments on fruit yield of eggplant against root-knot nematode and gall per plant.

Treatments	Number of nematodes/plant root	Number of galls/plant root	Gall index (0-10) scale	Yield (ton/ha)
T_1	4.33 c	5.83 b	3.33 b	0.633 c
T_2	4.00 c	5.67 b	3.16 bc	0.667 c
T_3	5.00 b	6.08 b	3.33 b	0.600 c
T_4	3.00 d	4.17 c	2.16 d	1.500 a
T_5	4.00 c	4.92 bc	3.16 bc	0.833 bc
T_6	4.00 c	4.33 c	3.16 bc	0.933 b
T_7	3.66cd	4.33 c	2.91 c	0.933 b
T_8	7.33 a	7.58 a	4.33 a	0.500 d
LSD	1.05	0.891	0.591	0.042
CV (%)	7.81	3.41	6.12	3.25

T_1 = Furadan 5G @ 60 kg/ha (12 gm/plot)

T_2 = Poultry refuse @ 10 ton/ha (2 kg/plot)

T_3 = Neembicidin @ 5ml/L water

T_4 = Furadan 5G+ Poultry refuse

T_5 = Furadan 5G+ Neembicidin

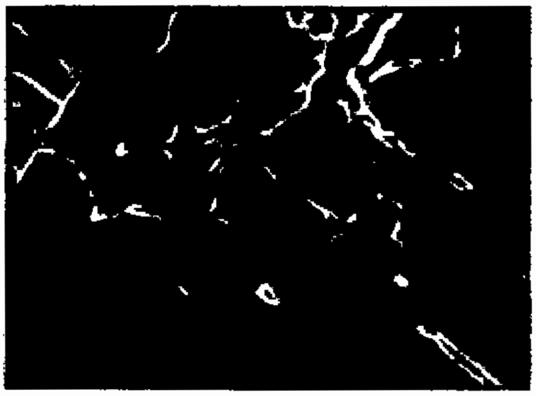
T_6 = Poultry refuse + Neembicidin

T_7 = Furadan 5G+ Poultry refuse + Neembicidin

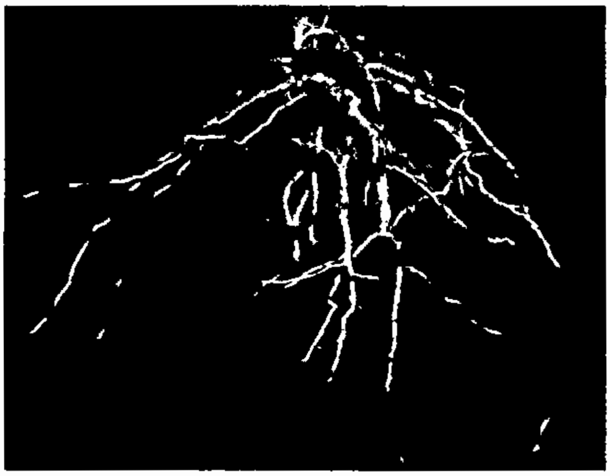
T_8 = Control

Each value is an average of three replications. Means bearing same letter within the same column do not differ significantly at 5% by DMRT.

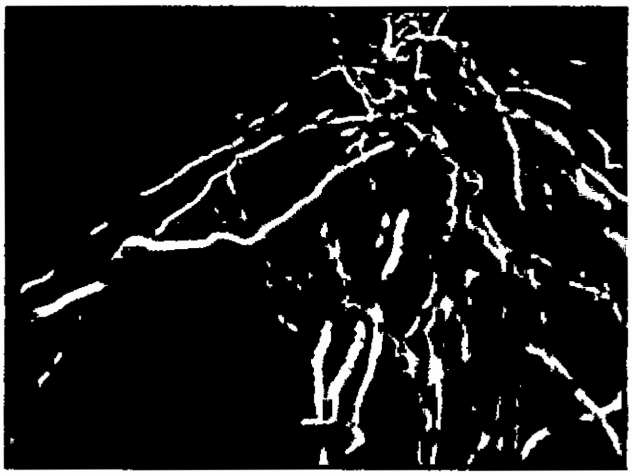
T_8



T_8



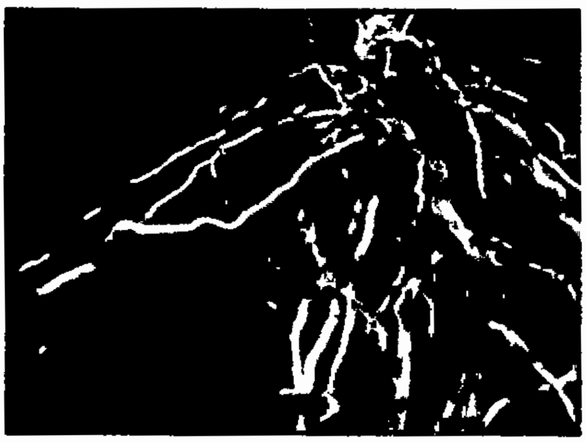
T_4



T_4

Photo-11 : Healthy and long roots of T_4 (Furadan 5G+Poultry Refuse) treatment and Galls Present in the roots of brinjal plant in control treatment (T_8)

T_8 T_8



T_4 T_4

Photo- 12 : Heavily infected root gall and short roots of control plants (T_8) and healthy roots of T_4 (Furadan 5G + Poultry refuse) treatment.

4.7 Number of galls / root:

Number of galls/root differed significantly in respect of different treatments (Table-2). The lowest number of galls/root 4.17 was obtained from the T_4, which received chemical nematicide Furadan 5G and poultry refuse. The second highest reduction was obtained from the teatment T_7 where Fuadan 5G, Poultry refuse and Nembicidin was applied. The third highest reduction of galls/root were resulted from the treatment T_6, and T_5, where poultry Refuse + Neembicidin and Furadan 5G+ Neembicidin were added, respectively . The highest number of galls/root 7.58 was counted from the control treatment (T_8). Application of Neembicidin alone (T_3) resulted 6.08 number of galls / root which was followed by T_1 (5.83 galls/root) and T_2 (5.67 galls/root) .Healthy and Gall infected root are shown Photo-11 and Heavily infected short roots and healthy roots are shown in the Photo-12.

4.8 Gall index (0-10) scale

From the present study it has been found that all the treatments reduced gall indices significantly over control treatment. The highest reduction of gall index in the brinjal plants (2.1) was calculated in the treatment T_4 where Furadan 5G and Poultry refuse were added. The second highest suppression of gall index (2.91) was calculated in the treatment T_7 where Furadan + Poultry Refuse + Neembicidin were added. The third highest reduction of gall indices (3.16), but statically similar with T_5 (3.16), T_2 (3.16) and T_1 (3.33) which received poultry refuse + Neembicidin, Furadan + Neembicidin, Furadan, poultry Refuse, respectively. The highest gall index (4.33) was resulted under the control treatment (T_8).

4.9 Yield (ton/ha)

The highest yield of brinjal plant 1.5 t/ha was obtained from the treatment T_4 followed by the treatment T_7 (0.93 t/ha), T_6 (0.933 t/ha) and T_5 (0.83 t/ha). The lowest yield (0.500 t/ha) was resulted from T_8 preceded by T_3 (0.60 t/ha), T_2 (0.667 t/ha), and T_1 (0.633 t/ha).

4.10 CORRELATION AND REGRESSION STUDY

4.10.1 Correlation and regression study between growth parameters and gall formation

Correlation study was done to determine the relationship between number of galls/plant and shoot and root length, fresh shoot and root weight. From the study it was revealed that significant and negative correlation were existing between gall number and shoot length (Fig.1) gall number and fresh shoot weight (fig.2) gall number and root length (Fig.3), gall number and fresh root weight (Fig.4), gall number and dry root weight (Fig.5), where the regression equation were y= -4.2796x + 96.026 (r2=0.909), Y= -33.825x + 403.25 (r2=0.5269), Y= -3.0981x + 36.772 (r2=0.6685), Y= -2.528x+28.373 (r2=0.5478), Y=-2.4569x+26.704 (r2=0.5428), respectively. The galling incidence hampered the crop growth in terms of shoot and root length along with shoot and root weight. Increases of gall number significantly reduced shoot and root length as well as shoot and root weight of plant. Treatment T_4 (Furadan 5G+Poultry refuse) and T_7 (Furadan 5G+Poultry refuse + Neembicidin) gave highest response and T_3 also gave moderate response in contributing the growth characters of brinjal plant by suppressing the nematode activities as evident with lower galling incidence.

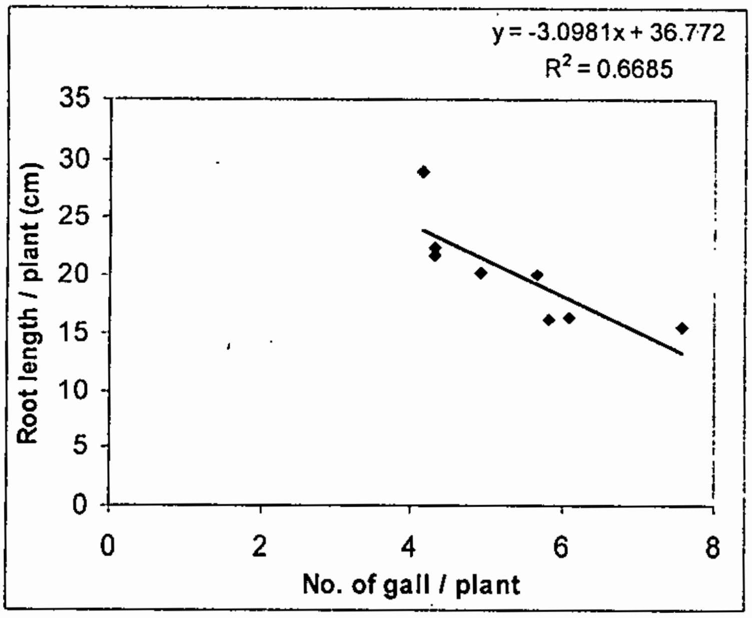


Fig.3. Relationship between gall number and fresh root length (cm) per plant in relation to root-knot incidence of brinjal plant after 95 days of transplanting.

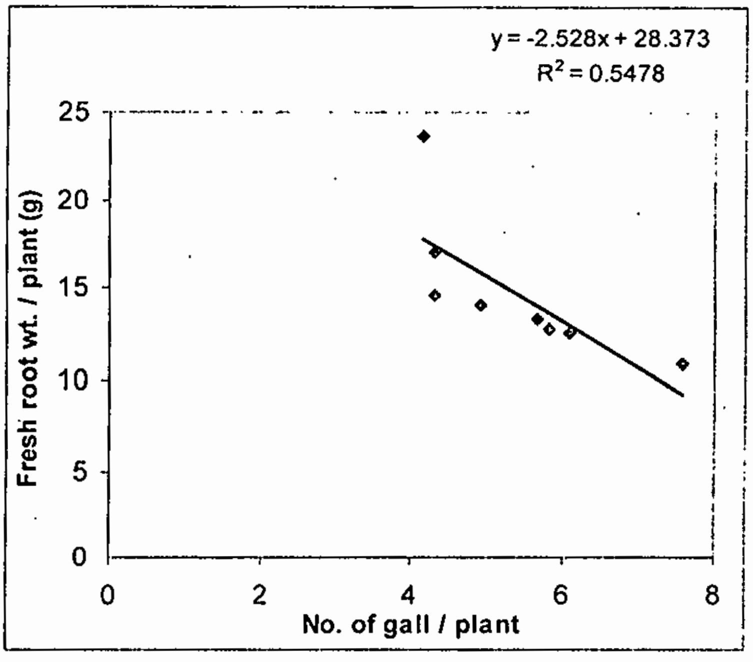


Fig.4. Relationship between gall number and fresh root weight (g) per plant in relation to root-knot incidence of brinjal plant after 95 days of transplanting.

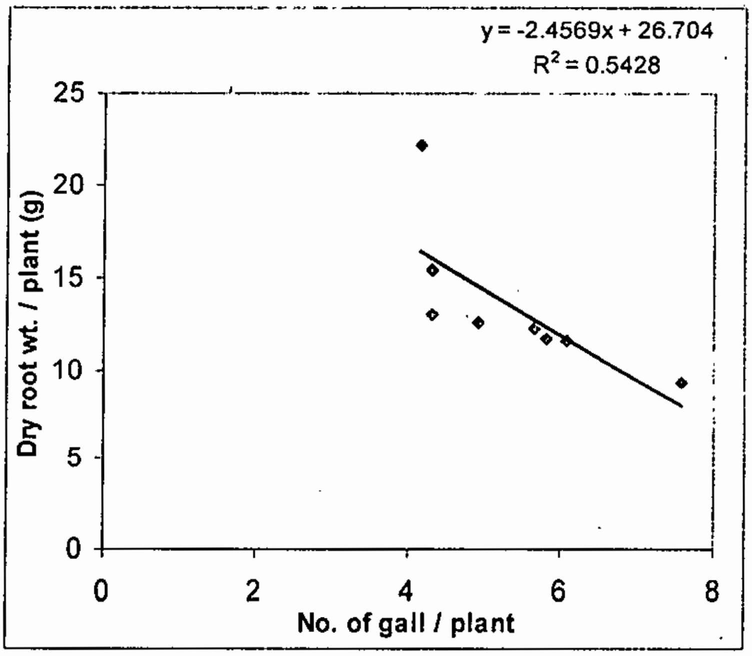


Fig.5. Relationship between gall number and dry root weight (g) per plant in relation to root-knot incidence of brinjal plant after 95 days of transplanting .s

DISCUSSION

The main objective of this study was to find out the suitable management practices that can be adapted easily to manage root-knot disease of brinjal caused by *Meloidogyne* spp. in the farmers field to increase the quality and production on of brinjal.

Result from the present study revealed that the chemical nematicides Furadan 5G, Poultry refuse and Neembicidin caused satisfactory reduction of nematode population and gall development on root of brinjal plant. Chemical nematicide Furadan 5G when applied alone caused significant reduction of root-knot nematode as reduced number of nematode population and gall. The findings of the present investigation on the root-knot nematode and increased plant growth characteristics of brinjal with Furadan 5G are similar with the results of many researchers in various crops. Similar control of root-knot nematode and increased plant growth and yield were obtained with carbofuran in brinjal (Mohanty, *et al.*2003) tomato (Zaki and maqbool,1995) potato Mian et al.,1991) and papaya (Gupta and sharma,1988).

All the treatments gave considerable increase in plant growth characters including shoot and root characteristics of brinjal plant. In general, organic materials when supplemented with nematicides were comperatively better than nematicides alone to decrease nematode development and to increase plant growth characters.

Among the organic amendments poultry refuse was considered to be the best amendment for nematode population and gall reduction. Effectiveness of poultry refuse is suppressing root knot nematode and increase plant growth and yield in pointed gourd, tomato and jute were reported by Anon (2003), Nahar *et al.* (1996), Wahudeniya (1991)and respectively.

All organic amendments were found to be promising for controlling root-knot of brinjal plant caused by *Meloidogyne* spp. Other investigators also achieved appreciable control of root-knot nematodes and increase in plant growth by treating nematode infested soil with neem leaf extract (Mishra *et al.* 1974, Nadal and Bhatti1986, Zaiyd 1977, Alam 1990, Ahmed and karim 1990), poultry refuse (Mian and Rodriguezkabana 1982, Mishra *et al.* 1987, Wahundeniya 1991, Nahar *et al.* 1996 and Marull et al.1997).

Results from the present study indicated that Furadan 5G was not much effective to reduce gall index, gall number, plant and root development over the control. But when Furadan 5G was applied with the combination of poultry refuse, these were more effective to reduce the gall index, gall number, and population of *Meloidogyne spp.* Their efficacy against root-knot nematodes within soil application or as seed treatment has been confirmed by many workers (Maqbol *et al.* 1985, Haq and Saxena 1986, Nganathan 1984, Gichure and Ondieki 1984, Zahid *et al.* 1992, Nahar *et al.*1996).

Adult female nematodes were observed under steriomicroscope after pinching the roots with needle on the slide. Due to the attack of nematodes, root growths were retarded and gall were found highest in the control. The combination of organic amendments with chemical nematicides Furadan 5G reduced gall index, no. of galls/root and no. of nematodes/root.

In this present study, it was found that nematicides alone reduced the root-knot infection of brinjal plant but it failed to give the satisfactory result in plant growth characteristics than the combination of organic amendments with nematicides. But best result was obtained when Furadan 5G was applied in the combination of poultry refuse/combination of organic amendments.

From the present study it has been found that the application of nematicides Furadan 5G with or without organic substrate like poultry refuse and neembicidin may be useful in the control of root-knot nematodes in the brinjal production.

SUMMARY AND CONCLUSION

It was found that the chemical nematicides alone controlled root knot nematodes but plant growth characters were not improved satisfactory.

But the combination of organic soil amendments with nematicides gave the best results in controlling root-knot and improving growth parameters of brinjal plants.

In general organic amendments were effective to induce plant growth and to reduce gall and nematode development.

Further study need to be carried out for consecutive years for including more options as management practices in different Agro Ecologicla zones (AEZ) of the country.

LITERATURE CITED

Agrios, G. N. 2000. Plant diseases caused by nematodes. Plant pathology. Harcourt Asia PIE LTD. 4th edition. pp 565-574.

Ahmad, M. U. and M. M. R. Bhuiyan. 1987. Efficacy of different method of application of granular chemicals against root knot disease of brinjal. Bangladesh J. Plant Pathology. **3**(1&2): 13-16.

Ahmed, H. U. and Hossain, M. 1985. Crop disease survey and establishment of herbarium at BARI. Final report of the project (1982-85), Plant Pathology Div. BARI, Joydebpur, Gazipur. pp107.

Ahmad, M.U. 1977. Effect of different levels of NPK fertilizers on the galling and early growth of eggplant (*Solanum melongena*) infected with *Meloidogyne incognita* (Kofoid and white) chitwood. An M. Sc. Thesis. Imperial collage of science and technology. University of London, U. K. 73p.

Ahmed M. U. and Karim, M.R. 1990. Effect of ten indigenous plant extracts on root knot nematodes of brinjal. Bangladesh J. Plant pathology 7(1&2): 5-9.

Akhtar, M. and I. Mahamood, 1996. Integrated nematode control in potato, *Solanum tuberosum*. J. International-pest-Control Society. **38**(2):62-64.

Ali, M. R. and I. H. Mian. 1989. Control of potato root knot nematode by cotton seed and mustard oil cakes. Bangladesh J. Plant Pathology. 5(1&2):7- 12.

Alam, M. M. 1990. Neem in nematode control. In nematode bio-control (Aspects and prospect) Delhi, India, CBS. pub. and Distributeds pvt. Ltd. 51-55. In Helminthol. Abs. 59:204.

Anonymous. 1997. Fertilizer recommendation guide. Bangladesh Agril. Res. Council, Farmgate, Dhaka. pp 70-71.

Anonymous. 2003. Annual report. 2002-2003. Plant pathology Division. BARI.

BARI, M. A. 2001. Biological Control of soil borne diseases of vegetables. Contract Research project, plant pathology Division, Bangladesh Agril. Res. Inst., Joydevpur, gazipur. pp 21-49.

BBS. 2005. Year Book of Agricultural Statistics of Bangladesh. Statistics Division, Bangladesh Bureau of Statistics (Monthly Statistical Bulletin, Bangladesh , December 2003) Ministry of planning, Government of the peoples republic of Bangladesh. 55p.

Bhagawati, B. and P. N. Phuka. 1990. Chemical control of *Meloidogyne incognita* on pea. Indian J. Nematol. **20**(1):79-83.

Biswas, A. K. 1979. Effect of different organic soil amendment on the development of root-knot disease on *Solanum melongina* at the early growth stage. An M. Sc. Thesis submitted to the Dept. of Plant Pathology, Bangladesh Agricultural University, Mymensingh Bangladesh.56pp.

Bora, B. C. and Phukan, P. N. 1983. Organic amendments for the control of root knot nematode on jute . J. Res., Assam-Agril. Univ., **4**(1):50-54 pp.

Chester, K. S. 1950. Nature and prevention of plant Disease. Mc-Grow Hill Book Co. Ltd. 2nd ed. pp 525.

Chowdhury, B. C. 1976. Phashaler Krimi Rog. Krishi Katha. pp 36:141.

Chhabra, H. K., P. S. Grewal and A. Singh. 1988. Efficacy of some plant extracts on root-Knot nematode (*Meloidogyne incognita).* J. Tree Sci. 7(1):24-25.

Darekar, K. S., N. L. Mhase and S. S. Shelke. 1990. Effect of placement of non edible oil seed cake on the control of root knot nematodes on tomato. Int. Nematol.Network News. 7(1):5-7.

Devappa, V., Krisnappa, K. and reddy, B. M. R. 1997. Management of root-knot nematode *Meloidogyne incognita* in sunflower. Mysore J. Agril. Sci. **31**(2):155-158.

D'errico, F. P. and F. Di Maio 1980. Effect of some organic materials on root knot nematodes on tomato in field preliminary experiments. Nematologica Med . **8**(1):107-110.

El-Nagdi, W. M. A. and M. A. A. Youssef . 2003. Efficacy of composted and non composed sugarcane residues in the control of *Meloidogvne incognita,* root knot nematode of okra. Pakistan J. Nematol . **21**(2):109-114.

Enokpa, k. N., Okwujiako, I. A. and Madungagu, B. E. 1996. Control of root-knot nematodes in tomato with Furadan. J. Pure and Applied Sci. **25**(2):131-136.

Fatema, S. E. and M. E. Sweelam. 2001. Effect of organic manure and potassium fertilizer on growth and nutrient uptake by faba bean plants grown in infested soil with root knot nematode. Annual of Agricultural Science-Cairo. **1**(Special): 315-329.

Gaur, H. S. and H. S. Gaur. 2003. Root knot disease of rice and wheat problem and management. IARI, New Delhi. 23p.

Gichure, E. and J. Ondieki. 1984. Control of root-knot nematode *Meloidogyne incognita* on tomato cv. early beauty in kenya by using four granular nematicides. Pakistan J. Nematol. Network Newsl. **5**(3):9.

Gupta, I. and G.L. Sharma. 1988. Chemical control trial against *Melodogyne incognita* on papya. Int. Nematol. Network News **15** (3) : 9.

Hammed, S. F. 1970. Note of effect of some organic additives on the incidence of root- knot nematodes in tomato (*Lycopersicon esculentum*) Indian Agric. Sci. 40: 207-210.

Hasan, A. 1991 Nematode Disease symptom, A Text Book of plant pathology. BARC, Farmgate. Dhaka-1212, pp 146-147.

Hasan, S. M. E. 1995. Comparative efficacy of granular and liquid appilication of Furadan 5G and Miral 3G against root-knot of brinjal. An M. S. thesis submitted to the department of plant Pathology, Bangladesh Agricultural University, Mymensingh. 60 pp.

Haq, S. and S. K. Saxena. 1986. Comparison of different modes of application of carbofuran for controlling *Meloidogyne incognita* on tomato. Indian J. Plant Pathology. 4(2): 187-188.

Hillocks, R. J. and Waller, J. M. 1997b. Assotiation between soil borne pathogen and other soil-inhabiting microorganisms. Cited in Soil borne disease of tropical crops, eds. R. J. Hillocks and J. M. Waller, CAB International. New york, USA. 358-359.

Homeyer, B. 1973. Curaterr a root systemic insecticide and nematicide. Melteilungenans der biologischen bmdesamstalt fur land and forstwests chaft, Berlin-Dahhen 151 : 203. (Helminth. Abstr. Series B19744 3(4) : 297).

Hossain, M. M. , Ali. M.,R. , Goswami, B. K. , Hossain. M. S. and Ali, M. R. 2003. Management of root knot nematode of brinjal with nematicide and organic amend to soil. Bangladesh Journal of plant Pathology. **19**(1/2):29-32.

Islam. M. M. 2005. Management of phomopsis blight and fruit rot of eggplant through chemicals and plant extracts. An M.S. thesis submitted to the Dept. of Plant Pathology, Sher-e-bangla Agricultural University, Dhaka-1207. 60 pp.

Katlon-Gateva, S. H., Stefanov, D. and Budurova, L. 1979. The effect of nematicides Furadan 10G on the species composition and population dynamics of soil and root nematodes on tobacoo. **8**:24-33.

Lee, M. J. 1978. The effect of extract of *Melia azadirachta* on *Meloidogyne incognita.* Quarter J. Chinesse Forestry. 20(4):1-7.

Mahamood, I., S. k. Saxena and Z. Uddin. 1982. Effect of certain plant extract on the mortality of *Rotylenchus reniformis* and *Meloidogyne incognita.* Bangladesh J. Botany 11(2): 154-157.

Maqbool, M. A., S. Hashmi and A. Ghafar. 1985. Effect of aldicarb and carbofuran on the control of root knot nematodes in cauliflower (*Brassica oleracea*). Int. Nematol. Network Newsl. **2**(3): 24-26.

Marull. J., J. Pinochet and R. Rodriguez-Kanana. 1997. Agriculture and municipal compost, residues for control of root-Knot nematodes in tomato and pepper. Secion de Experiment Medio Ambiental. Area Metropolitana de Barcelona, Barcelona, Spain. Compost Science and Utilization, **31**(5&1): 6-15.

Mesfin, A., Tessera, H. and Bekele. 1987. Evaluation of different control strategies against root-knot nematodes of Kenaf. College, Laguna, Philippines .

Mishra, S. D. and S. E. Prasad. 1974. Effect of soil amendments on nematodes and crop yields. Indian oil seed crops organic matter, inorganic fertilizer and growth regulators on nematodes associated with wheat and their residual effect on bean. Indian J. Nematol. **4**: 1-19.

Mian, I. H. and R. Rodriguez-Kanana. 1982. A survey of the nematicidal properties of some organic materials available in Alanama as amendments to soil for control of *Meloidogyne arenaria*. Nematropica **12**(2): 235-246.

Mian, I. H. 1986. Plant parasitic nematodes associated with some crop species in Bangladesh. Bangladesh J. Plant Pathol. **2**: 7-13.

Mishra, C. B., V. Singh and S. K. Laha. 1987. Integrated approach for the root-Knot nematode management in jute. India J. Nematol. **17**(2): 182-287.

Mian, I. H., M. S. Hossain and M. R. Ali, 1991. Efficacy of Furadan for control of root knot in potato. Bangladesh J. Plant Pathol. 7(1&2): 1-3.

Mian, I. H. (1994). Symptoms of nematode infestation. Introduction to nematology. IPSA-JICA Project. **23:** 55-56.

Mohanty, K. C., S. N. Mahapatra, R. V. Singh, Pankaj, S. C. Dhawan and H. S. Gaur. 2003. Biological control of root knot nematode infecting brinjal with *Pasteuria penetrans.* Procedings of national Symposium on Biodiversity and Management of Nematodes in cropping systems for sustainable Agriculture, Jaipur, India, 11-13 November, 2002-2003, 133-134.

Naganathan, T. G. 1984. Chemical control of *Meloidogyne incognita* in the nurseries. Nematol. Med. **12**(2) : 253-254.

Nanjegowda, D., N. Shivanandappa and C. Karegowda. 1985. Efficacy of soil amendments in control of root-knot nematodes in tobacco nursery J. Soil Biol. Ecol . **5**(2): 131-133.

Nadal, S. N. and D. S. Bharri. 1986. The effect of certain edaphic factors on organic soil amendments in control of root knot nematodes in tobacco nursery. J. Soil. Biol. Ecol. **5**(2): 131-133.

Nahar, S., M. I. Haq, M. S. Islam and M. H. Hossain. 1996. Effect of organic soil amendments for the management of root knot of tomato. Bngladesh J. Plant Pathol. **12**(1&2): 17-20.

Nanjegowda, D., Naik, B. G. Ravi, K. :Reddy, p. p. ;(ed), Kumar, N. K. K. (ed) and Verghese; A. 1998. Efficacy of neem products and a nematicide for the managemant of root knot nematode *Meloidogyne incognita* in tomato nursery. Advance in IPM for Horticultural crops. Proceedings of the First National Symposium on Pest management in Horticultural crops. Environmental implications and thrusts. Bangalore, India : 318-320.

Nonnecke, j. L. 1989. Vegetable production.Van Nostrand Reinhold, New York. pp 247.

Pathak, A. K., Yaday, B. S. and Brar, J. S. 1988. Water hyacinth and neem leaves for the control of root knot nematode *Meloidogyne incognita* on brinjal Plant Disease Research. pp 74-76.

Prakash, A., A. H. Wani and M. M. Alam. 2002. Effect of amendment with urea coated `Nimin' and oil of neem, castor and rocket salad on the root knot nematode *Meloidogyne incognita* and growth of okra. Tests of Agrochemicals and and Cultivars. no. 23:34-35.

Rashid, M. M. 1976. "Bangladesher Sabji" 1st Edn., Bangla Academy, Dhaka Bangladesh. pp 119-136.

Rahman, M. I., A. A. Evans and S. A. Miah. 1990. Plant damage and yield loss caused by rice root nematode *Meloidogyne graminicola in* water rice. Bangladesh J. Bot. **19**(2): 107-116.

Rashid, M. M. 1993. Sabjee baghan. Published by Bangla Academy, Dhaka. pp 137-144.

Rashid, M. M. 2000. AGuide book of plant Pathology. Dept. of plant Pathology. HSTU. Dinajpur. pp 58.

Rahman, M. H., Nahar, M. S., Rahman, M. A., Faruq, L., Jasmine, H. S., Alam, S., Black, L. and Miller, S. 2001. Management of soil borne pathogen of egg plant, cabbage and cucumber. IPM CRSP, Annual Report, No. pp **8** : 93-96 .

Sharma, C., P. C. Trivedi and B. Tiagi. 1985. Effect of green manuring on population of *M. incognita* muskmelon. Int. Nematol. Network Newsl. 2(1): 7-9.Sudha, S. and N. R. Prabhoo. 1983. *Meloidogyne* (Nematoda: Meloidogynidae) induced root galls of the banana o0lant *Muas paradisiaca* a study of histopathology. Preceedings of the indian Academy of Sci., Animal Sci**.**, **92**:89-94.

Sharma, H. K., R. V. Singh and G. Chawla. 2000. Evaluation of neemark and nimbicidine for management of root knot nematode, *Meloidogyne incognita* in okra. Indian J. Nematol . **30**(2): 256

Singh, R. S. and K. Sitaramaiah. 1973. Control of parasitic nematodes with organic amendments of soil. Final technical report. Effect of organic amendments, Green manures and inorganic fertilizer on root knot of vegetable crops. Ress. Bull. Expt, Stn. and Cott. Agric. G.B. Pant Univ. Agric. Tech. Pantanagar. 6: 289.

Siddiqui, Z. A., M. W. Khan and A. M. Khan. 1976. Nematode population and yield of certain vegetables as influenced by oil cake amendments. Indian J. Nematol. **2**(2): 179-182. In Helminthol Abstr. **48**(4): 1986-1979.

Siddiqui, M. A. and M. M. Alam. 1987. Effect of seed dressing with extracts of neem and perssian lilak against *Meloidotyne incognita* and *Rotylenchulus reniformis*. Nematol . Med. **15**(2): 399-403.

Singh, R.S and Sitaramaiah, 1994. Plant Pathogens, The Nematodes. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi. India. pp 175-177.

Singh, R. and K. Sitaramaiah. 1996. Incidence of root-knot of okra and tomato in oil cake amended soil. Plant Dis. Reptr. **50**(9): 666-672.

Singh, S., Goswami, B. K. and Singh, S. 2001. Studies on the management of disease complex caused by root-knot nematode, *Meloidogyne incognita* and wilt fungus, *Fusarium oxysporum* on cowpea by neem cake and carbofuran. Indian Journal of Nematology. **31** (2): 122-125.

Singh, R. S. and K. Sitaramaiah. 1973. Control of parasitic nematodes with organic amendments of soil. Final technical report. Effect of organic amendments, Green manures and inorganic fertilizer on root knot of vegetable crops. Ress. Bull. Expt, Stn. and Cott. Agric. G.B. Pant Univ. Agric. Tech. Pantanagar. 6: 289.

Siddiqui, Z. A., M. W. Khan and A. M. Khan. 1976. Nematode population and yield of certain vegetables as influenced by oil cake amendments. Indian J. Nematol. **2**(2): 179-182. In Helminthol Abstr. **48**(4): 1986-1979.

Siddiqui, M. A. and M. M. Alam. 1987. Effect of seed dressing with extracts of neem and perssian lilak against *Meloidotyne incognita* and *Rotylenchulus reniformis*. Nematol . Med. **15**(2): 399-403.

Singh, R.S and Sitaramaiah, 1994. Plant Pathogens, The Nematodes. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi. India. pp 175-177.

Singh, R. and K. Sitaramaiah. 1996. Incidence of root-knot of okra and tomato in oil cake amended soil. Plant Dis. Reptr. **50**(9): 666-672.

Singh, S., Goswami, B. K. and Singh, S. 2001. Studies on the management of disease complex caused by root-knot nematode, *Meloidogyne incognita* and wilt fungus, *Fusarium oxysporum* on cowpea by neem cake and carbofuran. Indian Journal of Nematology. **31** (2): 122-125.

Zaki, M. J. and M. A. Maqbool. 1995. Efficacy of nematicides in the control of root-knot nematode on tomato. Pakistan J. Nematol . **13**(2): 137-140.

Zarina, B., A. Gaffer and M. A. Maqbul. 2003. Effects of plant extracts in the control of *Meloidogyne javanica* root knot nematode on brinjal. Pakistan J. of nematol. **21**(1) : 31-35 ; 20.

Zeck, M. W. 1971. A rating scheme for field evaluation root-knot infestation. Pflanzenshufz Navhrichten Bayer 24 : 141-144.

Zeven, A. C. and Zhukivsky, P. M. 1975. Dictionary of cultivated plants and their centres of diversity, Wageningen. P. 219.

Zhang, Y. M. 1987. Vegetable root knot diseases and control. Shandong-Agricultural-science. No.3, 15-17.

Zaki, M. J. and M. A. Maqbool. 1995. Efficacy of nematicides in the control of root-knot nematode on tomato. Pakistan J. Nematol . **13**(2): 137-140.

Zarina, B., A. Gaffer and M. A. Maqbul. 2003. Effects of plant extracts in the control of *Meloidogyne javanica* root knot nematode on brinjal. Pakistan J. of nematol. **21**(1) : 31-35 ; 20.

Zeck, M. W. 1971. A rating scheme for field evaluation root-knot infestation. Pflanzenshufz Navhrichten Bayer 24 : 141-144.

Zeven, A. C. and Zhukivsky, P. M. 1975. Dictionary of cultivated plants and their centres of diversity, Wageningen. P. 219.

Zhang, Y. M. 1987. Vegetable root knot diseases and control. Shandong-Agricultural-science. No.3, 15-17.

APPENDICES

Appendix 1. Nutritive components in 100 gm of edible portion of brinjal Plant

Components	Composition
Moisture (%)	92.7
Protein (g)	1.4
Fat (g)	0.3
Minerals (g)	0.3
Fibers (g)	1.3
Carbohydrates (g)	4.0
Calcium (mg)	18
Magnesium (mg)	16
Oxalic acid (mg)	18
Phosphorus (mg)	47
Iron (mg)	0.9
Sodium	3.0
Potassium (mg)	2.0
Copper (mg)	0.17
Sulphur	44.0
Chlorine (mg)	52.0
Vitamin A I.U.	124
Thiamine (mg)	0.04
Riboflavin (mg)	0.11
Nicotinic acid (mg)	0.09
Vitamin C (mg)	12.0

Source : Vegetable crops in India TK. Bose and MG SOM

Appendix 2. Monthly mean of daily maximum, minimum and average temperature, relative humidity, total rainfall and sunshine hours during December/2005 to march/2006

Month	**Temperate (^0C)	Min.	Ave.	**Relative humidity (%)	*Rainfall (mm)	*Sunshine (hrs)
December	27.1	15.7	21.4	64.0	Trace	212.5
January	25.3	18.2	21.8	67.6	00	195.2
February	31.3	19.4	25.33	61.3	00	225.5
March	33.2	22.0	27.6	48.5	Trace	220.4

Source: Station name: PBO, Dhaka Station No: 41923, Surface synoptic data card, Bangladesh Meteorological Department, Sher-e-Bangla Nager, Dhaka-1207.

*=Monthly total

**=Monthly average