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DEVELOPMENT OF BIO-RATIONAL BASED MANAGEMENT PACKAGES AGAINST ROOT KNOT (*MELOIDOGYNE INCOGNITA*) OF BOTTLE GOURD

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Abstract

The efficacy of Tricho-compost alone and combination of lower dose of Furadan 5G with Tricho-compost, poultry refuse, neem oil cake and saw dust burning against root-knot nematode (*Meloidogyne incognita*) of bottle gourd was studied in the field laboratory of Plant Pathology Division of Bangladesh Agricultural Research Institute (BARI) during 2017 through 2019 cropping seasons. All the treatments gave appreciable reduction of gall development on roots and enhanced shoot and root growth as well as fruit yield of bottle gourd. Integration of Furadan 5G with Trichoderma based bio-fungicides. Tricho-composts, neem oil cake, and poultry refuse were the effective treatments in reducing root-knot severity and increasing plant growth and fruit yield of bottle gourd.

Keywords: Trichoderma, Tricho-compost, poultry refuse, neem oilcake, Furadan 5G, IPM, *Meloidogyne incognita*, bottle gourd.

Introduction

Bottle gourd (*Lagenaria siceraria* (Mol.) Standl.) is a para-tropical species under cucurbit family. It is also cultivated in India, Bangladesh, Sri Lanka, Indonesia, Malaysia, the Philippines, China, tropical Africa and South America. The crop is attacked by different devastating diseases and also different virus diseases (Zitter *et al*., 1996). Most of the diseases including root knot attack bottle gourd in Bangladesh. The root-knot nematodes (*Meloidogyne* spp.) have adversely affect both yield as well as quality of bottle gourd. Root-knot nematodes (*Meloidogyne* spp.) are considered the most damaging nematode group in the world (Luc *et al*., 2005). Root-knot nematodes causes an average 10% of yield loss for annual vegetables (Koenning *et al*., 1999). Several control measures were employed to control root-knot nematodes in infested areas. Chemical control of nematode pests remains the most effective control measure but with some serious constraints. Chemical nematicides are very toxic to the mammals and beneficial soil micro fauna/flora, pollute groundwater and have residual effect on farm produce. Researchers all over the world are engaged in standardizing the root-knot nematode management strategies by following non-chemical and eco-friendly alternative methods such as sanitation, soil management, organic amendments, fertilization and biological control methods to stabilize vegetable

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production (Collange *et al*., 2011). Many researchers have focused on the use of organic amendments to control plant-parasitic nematodes (Akhtar and Malik, 2000; Thoden *et al*., 2011). Singh and Patel (2015) reported that madar (*Calotropis procera*) and neem (*Azadirachta indica*) reduced *M. incognita* population and improved plant growth characters of bottle gourd. Biological control promises to be the most effective alternative for the management of root-knot nematode (Collange *et al*., 2011). Fungi and bacteria are among the most dominant soil-borne groups in natural soil ecosystem and some of them have shown great potential as biological control agents for root-knot nematodes (Kerry, 2000). The free-living soil fungi *Trichoderma* spp. are potential nematode bio-control agents on many food, vegetable and cash crops (Dababat and Sikora, 2007; Affokpon *et al*., 2011). Besides, *Trichoderma* spp. are common as soil beneficial bio-fertilizer belonging to plant growth promoting rhizobacteria have also been used for controlling root-knot nematodes (Padgham and Sikora, 2007). In Bangladesh all cucurbit vegetables are attacked by root knot nematode (Mian, 1986). Biological control of plant parasitic nematodes with antagonistic fungi is a promising technique which may be incorporated in integrated nematode management and gaining importance. Therefore, the present study was designed to develop bio-rational based integrated management packages of root knot nematode *M. incognita* infecting bottle gourd plants under field conditions.

Materials and Methods

The treatment efficacy of formulated *Trichoderma harzianum* called Tricho-composts, organic soil amendments, poultry refuse and neem oil cake and saw dust burning against root knot nematode disease of bottle gourd caused by *M. incognita* was investigated in the researchfield of Bangladesh Agricultural Research Institute (BARI), Gazipur during 2017-18 and 2018-19 cropping seasons. TwoTricho-composts (Tricho-compost-1 and Tricho-compost-2), poultry refuse, neem oil cake and saw dust were applied with lower dose of Furadan 5G.

Tricho-compost preparation: Commercially available *Trichoderma* inoculums (bioderma) were collected from Ispahani Agro Tech. Bangladesh Ltd. The collected inoculums were mixed with vermi-compost @ 1:20 (w/w) and kept for 7 days for multiplication of *Trichoderma* and designated as Tricho-compost-1. The previously, isolated virulent cultured of *T. harzianum* (TM7) by Plant Pathology Division, BARI was initially formulated in substrates containing a mixture of rice bran, wheat bran and mustard oilcake. The formulated *Trichoderma* was mixed with vermi-compost @ 1:20 (w/w) and kept for 7 days for multiplication of *Trichoderma* and designated as Tricho-compost-2.

Field experiment: The experiment was conducted in the research fields of BARI, Gazipur during 2017-18 and 2018-19, cropping years. There were altogether 8 treatments including control viz. (i) Tricho-compost-1 @ 2 kg/pit (ii) Tricho-compost-2 @ 2 kg/pit (iii) Tricho-compost-1 @ 2 kg/pit + Furadan 5G @ 20 g/pit (iv) Tricho-compost-2 @ 2 kg/pit + Furadan 5G @ 20 g/pit, (v) Poultry refuse @ 5-6 kg/pit + Furadan 5G @20 g/pit , (vi) Neem oil cake @ 500 g/pit + Furadan 5G @ 20 g/pit (vii) Saw dust burning + Furadan 5G @ 20 g/pit and (viii) Control without any materials. The experiment was laid out in a randomized complete block design (RCBD) with 4 replications. The unit pit size was 2 m x 2 m keeping 1m distance from pit to pit. Standard cultivation procedures recommended by BARI were followed to grow bottle gourd with little modification. The experimental land was prepared with proper tillage and fertilizers were added during final land preparation. Requisite amount of poultry refuse and neem oil cake were incorporated to the pit soil 3 weeks before seed sowing whereas Tricho-composts were added in the soils 5 days before seed sowing. The organic materials were properly mixed with the soil and kept moist for proper decomposition. In case of saw dust burning, 6 cm thick layer of dry saw dust cover with pit soil and burned the soil properly. After burning the ash were mixed with the soil. Furadan 5G was added at the time of seed sowing. The severely galled roots of tomato infected with *Meliodogyne incognita* were chopped and mixed with the pit soils @100 $gpit^{-1}$ before seed sowing. Seeds of bottle gourd var. BARI Lau-5 was sown in the pit soils and each pit received ten seeds. During crop season necessary weeding, irrigation and other intercultural operations were done as per recommendation for the crop (Azad *et. al.,* 2019). After 45-50 days of seed sowing, 2 seedlings were kept in each pit and the rest of the seedlings were uprooted carefully without disturb the root system and data were collected.

Data collection and analysis: Data on different parameters viz., plant height, plantweight, root length, root weight and yields were recorded. Gall index was recorded following 0-10 scale (Zeck, 1971). Data were analyzed statistically using the MSTAT-C computer program. The treatment means were compared using the least significant different (LSD) test at $P \leq 0.05$ level.

Results and Discussion

Severity of root-knot: The severity of root-knot disease of bottle gourd was reduced significantly over control due to soil treatment with Tricho-composts singly or integration with poultry refuse (PR), Tricho-composts, neem oilcake (NOC) and saw dust burning (SDB) with Furadan 5G (Table 1). In the first year, the maximum average gall index value of 5.13 was recorded in the control treatment and it ranged from 1.58 to 2.33 among different treatments. The lowest

root-knot severity of bottle gourd was recorded from the PR + Furadan 5G treatment, which was followed by NOC + Furadan 5G, Tricho-compost-2 + Furadan 5G, Tricho-compost-1 + Furadan 5G, Tricho-compost-2, SDB + Furadan 5G and Tricho-compost-1 (Table 1). Soil amendment with PR + Furadan 5G gave the maximum reduction of root-knot nematode disease severity (69.20%) over control which was followed by NOC+ Furadan 5G, Tricho-compost-2+ Furadan 5G, Tricho-compost-1+ Furadan 5G, Tricho-compost-2, SDB+ Furadan 5G and Tricho-compost-1 where the reduction values of root-knot nematode disease severity were 68.23, 67.25, 66.86, 59.45, 54.97 and 54.58%, respectively.

Table 1. Effect of soil treatment with Tricho-compost, poultry refuse, neem oil cake, sawdust burning and Furadan 5G on the root knot nematode disease severity of bottle gourd in soil inoculated with *Meloidogyne incognita*

Organic amendments, Tricho-composts and Furadan 5G with dose	Gall index (0-10 scale)		Reduction of gall index over control (%)	
	2017-18	2018-19	2017-18	2018-19
Tricho-compost-1 @ 2 kg/pit	2.33	1.50	54.58	57.14
Tricho-compost-2 @ 2 kg/pit	2.08	1.21	59.45	65.43
Tricho-compost-1 @ 2 kg/pit + Furadan 5G @ 20 g/pit	1.70	1.00	66.86	71.43
Tricho-compost-2 @ 2 kg/pit + Furadan 5G @ 20 g/pit	1.68	0.86	67.25	75.43
Poultry refuse @ 5-6 kg/pit + Furadan 5G @ 20 g/pit	1.58	0.73	69.20	79.14
Neem oil cake @ 500 g/pit + Furadan 5G @ 20 g/pit	1.63	1.15	68.23	67.14
Saw dust burning +Furadan 5G @ 20 g/pit	2.31	1.19	54.97	66.00
Control	5.13	3.50	-	-
LSD (0.05)	0.496	0.637	-	-

In the second year, significantly the highest gall index value of 3.50 was found in control plot and the values ranged from 0.73 to 1.50 under different treatments. The maximum reduction of 79.14% over control was obtained from the PR + Furadan 5G treatment followed by Tricho-compost-2+ Furadan 5G, Tricho-compost-1+ Furadan 5G, NOC+ Furadan 5G, SDB+ Furadan 5G, Tricho-compost-2 and Tricho-compost-1 where the reduction values of root-knot nematode disease severity were 75.43, 71.43, 67.14, 66.00, 65.43 and 57.14%, respectively (Table 1).

Plant growth: Soil treatment with Tricho-composts singly or integration with Tricho-composts, poultry refuse, neem oilcake and saw dust burning with Furadan 5G enhanced the plant growth viz. shoot length and shoot weight of bottle gourd as compared to control (Table 1). Average shoot length of bottle gourd under control treatment was 65.38 cm plant^{-1} in the first year and 84.00 cm plant^{-1} in the second year. Soil amendments with PR + Furadan 5G, NOC + Furadan 5G, SDB + Furadan 5G, Tricho-compost-2+Furadan 5G, Tricho-compost-1+Furadan 5G, Tricho-compost-2 and Tricho-compost-1 increased the plant height ranging from 95.90 to 112.60 cm in the first year and 122.50 to 132.50 cm in the second year. In the first year, soil amendments with PR + Furadan 5G and NOC + Furadan 5G gave the higher shoot length followed by Tricho-compost-2 + Furadan 5G, Tricho-compost-1 + Furadan 5G, NOC + Furadan 5G, Tricho-compost-2 and Tricho-compost-1 (Table 2). In the second year, all the treatment showed statistically similar effect in increasing shoot length compared to control (Table 2).

Table 2. Effect of soil treatment with Tricho-compost, poultry refuse, neem oil cake, sawdust burning and Furadan 5G on plant growth of bottle gourd in soil inoculated with *Meloidogyne incognita*

Organic amendments, Tricho-composts and Furadan 5G with dose	Shoot length (cm)		Shoot weight (g plant^{-1})	
	2017-18	2018-19	2017-18	2018-19
Tricho-compost-1 @ 2 kg/pit	95.90	122.50	269.6	296.3
Tricho-compost-2 @ 2 kg/pit	99.55	124.00	309.3	341.5
Tricho-compost-1 @ 2 kg/pit + Furadan 5G @ 20 g/pit	105.60	119.0	323.0	362.3
Tricho-compost-2 @ 2 kg/pit + Furadan 5G@ 20 g/pit	105.80	127.50	355.4	401.8
Poultry refuse @ 5-6 kg/pit + Furadan 5G @ 20 g/pit	110.70	132.50	402.3	487.5
Neem oil cake @ 500 g/pit + Furadan 5G @ 20 g/pit	112.60	127.30	402.1	400.5
Saw dust burning + Furadan 5G @ 20 g/pit	101.60	134.50	319.2	380.8
Control	65.38	84.00	190.2	253.8
LSD (0.05)	13.45	19.12	34.57	62.37

In first year, average shoot weight of bottle gourd was 190.2 g plant^{-1} in control plot and it was 269.6 to 402.3 g plant^{-1} among the treatments PR + Furadan 5G, NOC + Furadan 5G, SDB + Furadan 5G, Tricho-compost-2 + Furadan 5G,

Tricho-compost-1+ Furadan 5G, Tricho-compost-2 and Tricho-compost-1. Higher shoot weight was achieved with soil treatment with PR + Furadan 5G and NOC + Furadan 5G treatments, which was followed by Tricho-compost-2 + Furadan 5G, Tricho-compost-1 + Furadan 5G and NOC + Furadan 5G. The least effective treatment to increase plant weight was Tricho-compost-1, which was followed by Tricho-compost-2 and SDB + Furadan 5G. More or less similar trend was also observed in the second year trial. In second year, the lowest plant weight of bottle gourd was 253.8 g plant^{-1} in the control. Soil amendment with PR+ Furadan 5G gave the highest shoot weight (487.5 g plant^{-1}) followed by Tricho-compost-2 + Furadan 5G, NOC + Furadan 5G, SDB + Furadan 5G and Tricho-compost-1 + Furadan 5G, where the shoot weight was 401.8, 400.5, 380.8 and 362.3 g plant^{-1}, respectively. The least effective treatment was Tricho-compost-1 followed Tricho-compost-2 treatments where the shoot weight was 296.3 and 341.5 g plant^{-1}, respectively (Table 2).

Root growth: Amendment of soil with PR + Furadan 5G, NOC+ Furadan 5G, Tricho-compost-2 + Furadan 5G, Tricho-compost-1 + Furadan 5G, NOC + Furadan 5G, Tricho-compost-2 and Tricho-compost-1 showed positive effects on root growth of bottle gourd as compared to control (Table 3). In first year, the minimum root length of 17.38 cm plant^{-1} was recorded under control treatment. Soil amendment with PR + Furadan 5G, Tricho-compost-2 + Furadan 5G and NOC + Furadan 5G gave the higher root lengths of 31.83, 30.23 and 29.80 cm plant^{-1}, respectively followed by Tricho-compost-2,Tricho-compost-1 + Furadan 5G and SDB + Furadan 5G where the root lengths were 28.80, 28.30 and 26.80 cm plant^{-1}, respectively. In this yea,r the least effective treatment was Tricho-compost-1 with root length was 23.05 cm plant^{-1}. In second year, the lowest root length was 18.25 cm plant^{-1} was recorded in control plot. The maximum root length (26.50 cm plant^{-1}) was achieved in Tricho-compost-2 + Furadan 5G treatment which statistically similar effects was observed in Tricho-compost-1+ Furadan 5G, Tricho-compost-2, PR+ Furadan 5G, NOC + Furadan 5G, SDB + Furadan 5G and Tricho-compost-1 where root lengths were 25.75, 25.75, 25.50, 24.00, 23.50 and 21.00 cm plant^{-1}, respectively.

In the first year, minimum root weight of 10.57 g plant^{-1} was observed in control. The maximum root weight (23.85 g plant^{-1}) was recorded from PR + Furadan 5G treated plot followed by Tricho-compost-2+Furadan 5G, Tricho-compost-1+ Furadan 5G, NOC+ Furadan 5G and Tricho-compost-2 where root weights were 21.77, 20.58, 20.00 and 19.30 g plant^{-1}, respectively. Other treatments caused reduction in root weight ranging from 17.52 to 18.48 g plant^{-1}. However, in second year, root weight increased to some extent showing 8.50 g plant^{-1} in control plot and 12.75 to 15.50 g plant^{-1} in other plots (Table 3).

Table 3. Effect of soil treatment with Tricho-compost, poultry refuse, neem oil cake, sawdust burning and Furadan 5G on root growth of bottle gourd in soil inoculated with *Meloidogyne incognita*

Organic amendments, Tricho-composts and Furadan 5G with dose	Root length (cm)		Root weight (gplant^{-1})	
	2017-18	2018-19	2017-18	2018-19
Tricho-compost-1 @ 2 kg/pit	23.05	21.00	18.48	13.25
Tricho-compost-2 @ 2 kg/pit	28.80	25.75	19.30	14.75
Tricho-compost-1 @ 2 kg/pit + Furadan 5G @ 20 g/pit	28.30	25.75	20.58	15.00
Tricho-compost-2 @ 2 kg/pit + Furadan 5G @ 20 g/pit	30.23	26.50	21.77	14.50
Poultry refuse @ 5-6 kg/pit + Furadan 5G @ 20 g/pit	31.83	25.50	23.85	15.50
Neem oil cake @ 500 g/pit + Furadan 5G @ 20 g/pit	29.80	24.00	20.00	13.25
Saw dust burning +Furadan 5G @ 20 g/pit	26.80	23.50	17.52	12.75
Control	17.38	18.25	10.57	8.50
LSD (0.05)	5.99	7.709	4.89	3.017

Table 4. Effect of soil treatment with Tricho-compost, poultry refuse, neem oil cake, sawdust burning and Furadan 5G on the number of fruit setting of bottle gourd in soil inoculated with *Meloidogyne incognita*

Organic amendments, Tricho-composts and Furadan 5G with dose	Number of fruit plant^{-1}		Increased fruit plant^{-1} over control (%)	
	2017-18	2018-19	2017-18	2018-19
Tricho-compost-1 @ 2 kg/pit	18.00	19.50	31.94	33.33
Tricho-compost-2 @ 2 kg/pit	19.0	20.75	35.53	37.35
Tricho-compost-1 @ 2 kg/pit + Furadan 5G @ 20 g/pit	18.25	20.25	32.88	35.80
Tricho-compost-2 @ 2 kg/pit + Furadan 5G@ 20 g/pit	19.75	21.00	37.97	38.10
Poultry refuse @ 5-6 kg/pit + Furadan 5G@ 20 g/pit	19.50	21.25	37.18	38.82
Neem oil cake @ 500 g/pit + Furadan 5G@ 20 g/pit	18.50	19.75	33.78	34.18
Saw dust burning + Furadan 5G @ 20 g/pit	17.25	18.00	28.99	27.78
Control	12.25	13.00	-	-
LSD (0.05)	2.864	3.255	-	-

Crop yield: Soil amendments with PR+ Furadan 5G, NOC+ Furadan 5G, Tricho-compost-2+ Furadan 5G, Tricho-compost-1+ Furadan 5G, NOC+ Furadan 5G, Tricho-compost-2 and Tricho-compost-1 gave appreciable increase in fruit number /plant and fruit yield/ha in both the years though these were statistically similar (Tables 4 and 5).

Under control, fruit number per plant was 12.25 in the 1st year and 13.00 in the 2nd year. Fruit number per plant was increased (17.25-19.75 in 1st year and 18.00-21.25 in 2nd year) due to different treatments. In the 1st year, Tricho-compost-2+ Furadan 5G treatment increased fruit number with 26.87% over control followed by PR + Furadan 5G, Tricho-compost-2, NOC + Furadan 5G, Tricho-compost-1+ Furadan 5G, Tricho-compost-1 and SDB+ Furadan 5G where the fruits number was 37.18, 35.53, 33.78, 32.88, 31.94 and 28.99%, respectively (Table 4). In the 2nd year, PR + Furadan 5G gave the highest increased of fruit number with 38.82% over control, which was statistically similar to other treatments (Table 4).

Table 5. Effect of soil treatment with Tricho-compost, poultry refuse, neem oil cake, sawdust burning and Furadan 5G on yield of bottle gourd in soil inoculated with *Meloidogyne incognita*

Organic amendments, Tricho-composts and Furadan 5G with dose	Fruit yield (tha^{-1})		Yield increased over control (%)	
	2017-18	2018-19	2017-18	2018-19
Tricho-compost-1 @ 2 kg/pit	65.00	59.38	33.65	13.69
Tricho-compost-2 @ 2 kg/pit	68.13	64.38	36.69	20.39
Tricho-compost-1 @ 2 kg/pit + Furadan 5G @ 20 g/pit	68.75	66.25	37.27	22.64
Tricho-compost-2 @ 2 kg/pit + Furadan 5G @ 20 g/pit	72.50	66.88	40.51	23.38
Poultry refuse @ 5-6 kg/pit + Furadan 5G @ 20 g/pit	75.00	75.50	42.49	32.12
Neem oil cake @ 500 g/pit + Furadan 5G @ 20 g/pit	72.50	68.75	40.51	25.45
Saw dust burning + Furadan 5G @ 20 g/pit	67.25	63.75	35.87	19.61
Control	43.13	51.25	-	-
LSD (0.05)	9.101	9.48	-	-

In first year, the fruit yield was the lowest (43.13 $t.ha^{-1}$) in control treatment and higher (65.00 to 75.00 $t.ha^{-1}$) among treatments PR + Furadan 5G, NOC+ Furadan 5G, Tricho-compost-2 + Furadan 5G, Tricho-compost-1+ Furadan 5G,

NOC + Furadan 5G, Tricho-compost-2 and Tricho-compost-1 (Table 5). The maximum fruit yield was obtained with PR + Furadan 5G treatment where fruit yield was 42.49% higher compared to control which followed by Tricho-compost-2 + Furadan 5G, NOC + Furadan 5G, Tricho-compost-1+ Furadan 5G, Tricho-compost-2, SDB + Furadan 5G, and Tricho-compost-1 with the yields of 40.51, 40.51, 37.27, 36.69, 35.87 and 33.65%, respectively. In the 2nd year, average fruit yield of control plot was 51.25 $t.ha^{-1}$ and other treatment ranged from 59.38 to 75.50 tha^{-1}. The maximum fruit yield (75.50 $t.ha^{-1}$) was obtained with PR + Furadan 5G treatment followed by NOC + Furadan 5G, Tricho-compost-2 + Furadan 5G, Tricho-compost-1 + Furadan 5G, Tricho-compost-2 and SDB + Furadan 5G with the fruit yields of 68.75, 66.88, 66.25, 64.38 and 63.75 $t.ha^{-1}$, respectively (Table 5). The maximum increase of yield (32.12%) over control was in PR + Furadan 5G treatment which was followed by NOC+ Furadan 5G, Tricho-compost-2 + Furadan 5G, Tricho-compost-1+ Furadan 5G, Tricho-compost-2 and SDB+ Furadan 5G with the fruit yield increase of 25.45, 23.38, 22.64, 20.39 and 19.61%, respectively (Table 5).

The present study was designed to determine the potentiality of soil treatment with bio-products, Tricho-composts containing biological control agent *T. harzianum* or integration of Tricho-composts with chemical nematicide, Furadan 5G or integration of organic amendment viz. poultry refuse and neem oilcake with Furadan 5G as well as saw dust burning with Furadan 5G in suppression of root-knot nematodes and increasing plant growth as well as fruit yield of bottle gourd in the field. The results demonstrate that integrated soil amending with Tricho-composts with Furadan 5G, poultry refuse with Furadan 5G and neem oil cake with Furadan 5G drastically suppressed gall index valued caused by root-knot nematode *M. incognita* and improving plant growth parameters such as shoot length, shoot weight, root length and root weight as well as fruit yield of bottle gourd compare to control. Soil amendment with Tricho-composts alone as well as integration of saw dust burning with Furadan 5G also reduced gall index values and improved plant growth to some extend whereas integration of Tricho-composts with Furadan 5G, poultry refuse with Furadan 5G and neem oil cake with Furadan 5G was inferior in general. These results were supported by the findings of Mostafa (2001) who reported that the integrated of caster + *A. oligospors* + oxamyl was effective in reducing the nematode population and increase plant growth and yield compared to each treatment alone. Combining neem cake amendments with *P. penetrans* gave encouraging results (Javed *et al.*, 2008). Sundaram and Thangaraj (2001) also reported a reduction of *M. incognita* population when *T. harzianum* were applied as a seed treatment. The fungal bioagent *T. harzianum* showed their bio-efficacy against *M. incognita* in reducing their reproduction rate as compared to the untreated control (Sahebani and Hadavi, 2008; Singh *et al*, 2011; Khan and Haque, 2011). Similarly, Lal and Rana (2013) recorded the lowest number of galls, egg masses and final nematode population of *M. incognita* in okra plants treated with *T. harzainum*. Many other

researchers also confirmed previous findings, on the use of isolates of *Trichoderma* spp. for the management of root-knot nematodes in vegetable crops (Dababat and Sikora, 2007; Sahebani and Hadavi, 2008; Affokpon *et al*., 2011). Soil amendment with poultry refuse or integration of poultry refuses with nematicde Furadan 5G was found effective against root-knot nematode of bottle gourd (Khan, 1996). Beneficial effects of organic wastes, poultry manure on nematode control and crop growth were also observed by other researchers (Akhtar and Malik 2000; Abubakar and Adamu 2004; Orisajo *et. al*., 2007). Akhtar and Malik (2000) repeatedly tested neem (*Azadirachta indica*) oil cake, and found that it was particularly efficient against root-knot nematodes even at low dosages (1 to 2 t/ha). Several studies reported that oil cake applications reduced the *Meloidogyne* spp. population and thereby increasing plant growth and yield of different crops (Yadav *et al*., 2005; Nirosha *et al.*, 2018).

Conclusion

The present study provides evidence that integration of poultry refuse, Trichoderma based bio-fungicide called Tricho-composts and neem oil cake with minimum dose of nematicide Furadan 5G were the effective in reducing root-knot (*M. incognita*) disease, as well as increasing plant growth and fruit yield of bottle gourd. Soil treatment with Tricho-composts alone or integration of saw dust burning with Furadan 5G also performed better in reduction of root-knot nematode disease and increasing plant growth as well as yield of bottle gourd. The obtained results were seemed to be an alternative for the control of *M. incognita* in bottle gourd under field condition.

References

Abubakar, U. and Adamu, T. 2004. Control of *Meloidogyne incognita* (Kofoid and White) Chitwood of tomato (*Lycopersicon lycopersicum* Karst) using camel dung. Journal of Tropical Biosciences, **47:** 1–3.

Affokpon, A., Coyne, D. L., Htay, C. C., Agbèdè, R. D., Lawouin, L. and Coosemans, J. 2011. Biocontrol potential of native *Trichoderma* isolates against root-knot nematodes in West African vegetable production systems. Soil Biology and Biochemistry **43:** 600–608.

Akhtar, M. and Malik, A. 2000. Roles of organic soil amendments and soil organisms in the biological control of plant-parasitic nematodes: a review. Bioresour. Technol. **74:**35-47.

Arora, R., Battu, G. S. and Ramakrishnan, N. 2000. Microbial pesticides: current status and future outlook. In: Dhaliwal, G.S., Singh, B. (Eds.), Pesticides and Environment. Commonwealth Publishers, New Delhi, pp. 344–395

Azad, A. K., M. A. Wahab, M. G. Saha, J. Nesa, M. L. Tahman, M. H. H. Rahman and M. Al-Amin. 2019, Edited: KRISHI PROJUKTI HATBOI (Handbook on Agro-Technology), 8th edition. Bangladesh Agricultural Research Institute, Gazipur, Bangladesh. pp 160-163.

Collange, B., Navarrete, M., Peyre, G., Mateille, T. and Tchamitchian, M. 2011. Root-knot nematode (*Meloidogyne*) management in vegetable crop production: the challenge of an agronomic system analysis. Crop Protection **30:** 1251–1262

Dababat, A. A. and Sikora, R. A. 2007. Use of *Trichoderma harzianum* and *Trichoderma viride* for the biological control of *Meloidogyne incognita* on tomato. *Jordan J. of Agril. Sci.* **3:** 297–309.

Javed, N., S. El-Hassan, S. Gowen, B. Pemproke and M. Inam-Ul-Haq. 2008. The potential of combining *Pasteuria penetrans* and neem (Azadirachta indica) formulations as a management system for root-knot nematodes on tomato. Eur. J. Plant Pathol. **120:**53-60.

Kerry, B.R., 2000. Rhizosphere interactions and the exploitation of microbial agents for the biological control of plant-parasitic nematodes. Annual Review of Phytopathology **38:** 423–441.

Khan, M. R. and Z. Haque. 2011. Soil application of Pseudomonas fluorescens and *Trichoderma harzianum* reduces root-knot nematode, Meloidogyne incognita, on tobacco. Phytopathologia Mediterranea. **50:** 257−266.

Khan, A.G., 1996. Efficacy of chemical and soil amendments with mustard oil cake on the root-knot (*Meloidogyne javanica*) of bottle gourd. M.S. Thesis, Faculty of Agriculture, BAU, Mymensingh. 59p.

Koenning, S.R., Overstreet, C., Noling, J.W., Donald, P.A., Becker, J.O., Fortnum, B.A., 1999. Survey of crop losses in response to phytoparasitic nematodes in the United States for 1994. J. Nematol. **31:** 587-618.

Lal, B. and Rana, B.P. 2013. Evaluation of fungi as seed and soil treatment against root-knot nematode, *Meloidogyne incognita* in okra. Agricultural Science Digest. **33** (3): 226-229.

Luc M, Sikora RA, Bridge J (Eds.) 2005. Plant Parasitic Nematodes in Subtropical and tropical Agriculture, 2th edition: Wallingford, U.K. CABI Publishing.

Mian, M. I. 1986. Plant parasitic nematode associated with some crop species in Bangladesh. Bangladesh J. Plant Pathol. **2**(1): 7-13.

Mostafa F. A. 2001. Integrated control of root-knot nematodes, *Meloidogyne* spp. infected sunflower and yomato. Pakistan journal of biological science, **4** (1):44-46.

Nirosha, A., Rajeshkanna, S. and Mikunthan, G. 2018. Effect of oil cakes and garlic aqueous based formulations of *Trichoderma viride* on management of *Meloidogyne incognita* in chilli. Open Agriculture **3:** 214–219

Orisajo, S. B., Okeniyi, M. O., Fademi, O. A. and Dongo, L. N. 2007. Nematicidal effects of water leaf extracts of *Acalypha ciliata*, *Jatropha gossypi folia*, *Azadirachta indica* and *Allium ascalonicum* on *Meloidogyne incognita* infection on cacao seedlings. J. of Res. in Bioscience **3** (3): 49-53.

Padgham, J. L. and Sikora, R. A. 2007. Biological control potential and modes of action of *Bacillus megaterium* and *Meloidogyne graminicola* on rice. Crop Protection **26:** 971–977.

Sahebani, N. and Hadavi, N. 2008. Biological control of the root-knot nematode *Meloidogyne javanica* by *Trichoderma harzianum*. Soil Biology and Biochemistry **40:**2016–2020.