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BIO-RATIONAL MANAGEMENT FOR ROOT-KNOT DISEASE OF TOMATO CAUSED BY *MELOIDOGYNE INCOGNITA*

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Abstract

The experiments were conducted during two consecutive cropping seasons of 2017-19 to develop bio-rational based eco-friendly integrated management of root-knot diseases of tomato caused by *Meloidogyne incognita*. The root knot nematode (RKN) infested soils were treated with a different combination of *Trichoderma* based Tricho-compost and neem oil cake with or without low dose of chemical nematicide Furadan 5G. All the treatments gave appreciable reduction of gall development in roots, increased plant growth parameters such as shoot and root growth and fruit yield of tomato. Among the treatments, integration of Tricho-composts with Furadan 5G or neem oil cake integrated with Furadan 5G proved better. However, Trichoderma based bio-fungicides Tricho-composts alone produced promising results but integration of Tricho-composts with Furadan 5G or neem oil cake integrated with Furadan 5G could be the best for management of root knot nematode.

Keywords: Tomato, root-knot nematode**,** *Meloidogyne incognita*, Tricho-compost, neem oil cake, Furadan 5G.

Introduction

Tomato *(Lycopersicon esculentum* L.) is one of the most popular high value vegetable crops grown throughout the world including Bangladesh. The average yield of tomato in Bangladesh is 14.93 t/ha (BBS 2022) which is quite low as compared to that of other tomato producing countries in the World (Anonymous, 1998). Various factors such as lack of good quality seed and incidence of diseases and pests have been identified for low yield of tomato in Bangladesh. Among the diseases, nematodes are important economical pests of horticultural crops including tomato (Afroz *et al*., 2008; Aktar *et al*., 2008; Tipu *et al*., 2021; Akhter *et al*., 2019). Severe infestation of nematodes can lead to yield losses of over 30% in highly susceptible vegetable crops (Sikora and Fernandez, 2005). The average losses due to root-knot nematode infestation are 20.6% in tomato (Sasser, 1989) and go up to 40% (Singh and Kumar, 2015). Root-knot nematode has been considered as a major limiting factor in the production of tomato throughout Bangladesh (Mian, 1986).

Various strategies for controlling root-knot nematodes, application of nematicides (Hossain *et al.*, 1989), organic soil amendments (Faruk *et al.*, 2001*;* Bari *et al.*,

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2004), cultural, physical measures and biological measures (*Trichoderma* spp, *Pacecilomyces lilacinus, Pasturia penetrans* and *Pseudomonas aeruginosa*) (Rao *et al*., 1997; Reddy *et al.*, 1998 and Siddiqui *et al*., 1999) are practicing. Use of resistant cultivar would be an effective control measure against the disease but none of the tomato varieties cultivated in the country is resistant against the disease. The indiscriminate use of chemicals insisted the appearance of resistant micro-organisms leading to the occurrence of emerging soil borne diseases and also degrading to the environment, other beneficial soil microbes and human health (Akinpelu, 2001; Wachira *et al*., 2009). Therefore, an alternative management option of root-knot nematode disease management is urgently needed. Most effective alternative management option of root-knot nematode is biological control. In the facts mentioned above, the present study was undertaken to develop an eco-friendly management option against root-knot nematode disease of tomato.

Materials and Methods

The experiment was conducted during two consecutive cropping seasons of 2017-2019 in the field of Plant Pathology Division of BARI, Joydebpur, Gazipur with 7 treatment combinations. The treatments were (i) Furadan 5G @ 45 kgha^{-1}, (ii) Tricho-compost-1@ 3 tha^{-1}, (iii) Tricho-compost-2@ 3 tha^{-1}, (iv) Tricho-compost-1@ 3 tha^{-1}+ Furadan 5G @ 25 kgha^{-1}, (v) Tricho-compost-1@ 3 tha^{-1}+ Furadan 5G @ 25 kgha^{-1}, (vi) Neem oil cake @ 500 kgha^{-1}+ Furadan 5G @ 25 kgha^{-1}, and vii) Untreated control. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The unit plot size was 3m x 3m. The tomato seedlings were transplanted keeping plant to plant distance 50 cm and line-to-line distance 60 cm. The field soil was inoculated with @ 1 gm of *Melodogyne incognita* infected galled chopped roots of Indian spinach per plant at the time of seedling transplanting. Trichoderma inoculum (bioderma) collected from the Ispahani Agro Tech. Bangladesh, was mass-multiplied in vermi-compost and it was designated as Tricho-compost-1. The *T. harzianum* isolates collected from Plant Pathology Division was multiplied in the mixture of grass pea and wheat bran with mustard oilcake substrates. Mass multiplication of the formulated *Trichoderma* was made in vermi-compost and it was designated as Tricho-compost-2. Tricho-composts were added @ 3 tha^{-1} at 5 days before seedling transplanting, mixed properly with soil and kept for Trichoderma establishment in soil. Neem oilcake was applied at 21 days before seedling transplanting and was properly mixed with the soil and kept moist for proper decomposition. Furadan 5G was added before seedling transplanting. Twenty-five days old tomato seedlings of tomato var. BARI Tomato-15, grown on sterilized soils, were transplanted in the field. Fertilizers, weeding, and irrigation were applied as per recommendation of the crop.

Data collection and analysis: Data on different parameters viz. shoot height, shoot weight, root length, root weight, fruit number per plant and yield of tomato were taken. During the growing period bacterial wilt incidence was recorded from seedling to maturity stage. The severity of root-knot nematode disease was recorded as gall index following 0-10 scale (Zeck, 1971). Data were analyzed statistically by using the MSTATC program and treatments were compared by least significant different (LSD) test at P=0.05 level.

Results and Discussion

Reduction of root-knot nematode (RKN) disease severity: The severity of root-knot nematode disease of tomato was reduced significantly over control due to soil treatment with Tricho-composts alone or combination with lower dose of Furadan 5G as well as integration of neem oil cake (NOC) with Furadan 5G (Table 1). In the first year, the maximum average gall index 6.13 was recorded in the untreated control plot. The root gall index was reduced from 2.00 to 2.47 due to soil treatments with Tricho-composts, and also integration of Tricho-compost and NOC with Furadan 5G. The lowest RKN disease severity of tomato was recorded from the treatments with NOC @ 500 kg/ha + Furadan 5G @ 25 kgha^{-1} and Tricho-compost-2 @ 3 tha^{-1} + Furadan 5G @ 25 kgha^{-1}, which was followed by Tricho-compost-1 @ 3 tha^{-1} + Furadan 5G @ 25 kgha^{-1}, Tricho-compost-2 @ 3 tha^{-1} and Tricho-compost-1 @ 3 tha^{-1}. Furadan 5G @ 45 kgha^{-1} alone gave higher root gall index (Table 1). Integration of Furadan 5G with NOC and Tricho-compost-2 gave the highest reduction 67.37% of RKN disease severity followed by Tricho-compost-1 + Furadan 5G (65.25%) (Table 1). Besides, the highest gall index value of 5.08 was found in control plot and the values were reduced from 1.08 to 1.92 due to application of different treatments during the second-year experiment. The reduction in disease severity was significant compared to control treatment. The maximum reduction of RKN disease 78.74% was obtained with NOC @ 500 kg/ha + Furadan 5G @ 25 kgha^{-1} followed by Tricho-compost-1 @ 3 tha^{-1} + Furadan 5G @ 25 kgha^{-1}, Tricho-compost-2 @ 3 tha^{-1} + Furadan 5G @ 25 kgha^{-1} with the reduction of 74.61% and 73.82%, respectively compared to control. Individually Tricho-compost-2 @ 3 tha^{-1}, Furadan 5G @ 45 kgha^{-1}, and Tricho-compost-1 @ 3 tha^{-1} reduced 72.04%, 72.04% and 62.20%, respectively root knot nematode disease compared to control (Table 1).

Shoot growth: Average shoot length of tomato under control treatment was 55.20 cm plant^{-1} in first year and 64.63 cm plant^{-1} in second year (Table 2). Treatment of soil with Tricho-compost-1 and Tricho-compost-2 alone or integration of Tricho-compost and NOC with Furadan 5G increased the parameter from 77.93 to 83.00 cm plant^{-1} and 79.90 to 98.70 cm plant^{-1}t of first and second year respectively. . In the first year, higher shoot length was obtained by NOC + Furadan 5G ^{1}, Tricho-compost-1 + Furadan 5G ^{1}, Tricho-compost-2 + Furadan 5G followed by Tricho-compost-1, Tricho-compost-2 and Furadan 5G. Similar trend was observed in the second year followed by Tricho-compost-2. The least effective treatment was Furadan 5G @ 45 kgha^{-1} followed by Tricho-compost-1 @ 3 tha^{-1}.

Table 1. Effect of two Tricho-composts, organic amendment and nematicide on the severity of root -knot disease *(Meloidogyne incognita)* of tomato

Treatments	Gall index at harvest (0-10 scale)		Gall index reduction over control (%)	
	1st year	2nd year	1st year	2nd year
Furadan 5G @ 45 kgha^{-1}	2.93 b	1.42 bc	52.20	72.04
Tricho-compost-1 @ 3tha^{-1}	2.47 c	1.92 b	59.71	62.20
Tricho-compost-2 @ 3tha^{-1}	2.33 cd	1.42 bc	61.99	72.04
Tricho-compost-1 @ 3tha^{-1}+ Furadan 5G@ 25 kgha^{-1}	2.13 cd	1.29 bc	65.25	74.61
Tricho-compost-2 @3tha^{-1}+ Furadan 5G@ 25 kgha^{-1}	2.00 d	1.33 bc	67.37	73.82
Neem oil cake @ 500 kgha^{-1}+ Furadan 5G @ 25 kgha^{-1}	2.00 d	1.08 c	67.37	78.74
Control	6.13 a	5.08 a	-	-
LSD (P=0.05)	0.373	0.832	-	-

Values within the same column with a common letter do not differ significantly (P=0.05).

Table 2. Effect of Tricho-composts, neem oilcake and nematicide on shoot growth of tomato in soil inoculated with *Meloidogyne incognita.*

Treatments	Shoot growth (cm/plant)		Shoot weight (gm/plant)	
	1st year	2nd year	1st year	2nd year
Furadan 5G @ 45 kgha^{-1}	77.93 b	79.90 c	280.00 d	226.4 bc
Tricho-compost-1 @ 3tha^{-1}	78.20 b	87.10 bc	290.60 d	253.0 ab
Tricho-compost-2 @ 3tha^{-1}	79.47 b	93.03 ab	312.40 c	267.9 a
Tricho-compost-1 @ 3tha^{-1} + Furadan 5G@ 25 kgha^{-1}	82.20 a	98.23 a	357.70 b	275.4 a
Tricho-compost-2 @3tha^{-1} + Furadan 5G@ 25 kgha^{-1}	83.00 a	96.67 a	373.10 a	283.9 a
Neem oil cake @ 500 kgha^{-1} + Furadan 5G @ 25 kgha^{-1}	82.60 a	98.70 a	382.40 a	282.8 a
Control	55.20 c	64.63 d	208.90 e	191.7 c
LSD (P=0.05)	4.883	9.018	12.86	39.24

Root growth: Soil amendment with Tricho-compost and NOC either singly or in combination with low dose of Furadan 5G showed positive effects on root growth of tomato as compared to untreated control (Table 3). In the first year, minimum root length of 16.07 cm plant^{-1} was recorded under control treatment. The highest root length of 20.67 cm was achieved from NOC @ 500 kg/ha + Furadan5G @ 25 kg/ha and Tricho-compost-2 @ 3 t/ha + Furadan5G @ 25 kg/ha. Besides, the Tricho-compost-1 @ 3 t/ha + Furadan5G @ 25 kg/ha, Tricho-compost-2 @ 3 t/ha and Tricho-compost-1 @ 3 t/ha gave root length per plant 20.13 cm, 19.73 cm, and

19.13 cm, respectively. Application of Furadan 5G alone increased the root length over control in both the year. In first year, root weight was as low as 18.97 g/plant under control. The maximum root weight of 27.70 g/plant was recorded from Tricho-compost-2 @ 3 t/ha + Furadan5G @ 25 kg/ha treatment followed by NOC @ 500 kg/ha + Furadan5G @ 25 kg/ha treatment of root weight (25.89 g/plant). The root weights ranging from 21.91 to 24.70 g/plant was observed other treatment. However, in second year, the root weight was increased to some extent over control (29.60 g/plant) and it ranged from 31.20 to 34.37 g/plant in plots treated with Tricho-compost and integration of Tricho-composts and NOC with lower dose of Furadan 5G (Table 3).

Table 3. Effect of Tricho-composts, organic amendments and nematicide on root growth of tomato in soil inoculated with *Meloidogyne incognita*

Treatments	Root length (cm/plant)		Root weight (gm/plant)	
	1st year	2nd year	1st year	2nd year
Furadan 5G @ 45 kgha^{-1}	20.13 ab	19.93 bc	24.70 bc	32.73
Tricho-compost-1 @ 3tha^{-1}	18.47 b	23.10 ab	22.09 d	31.20
Tricho-compost-2 @ 3tha^{-1}	20.67 a	24.07 ab	23.50 cd	32.23
Tricho-compost-1 @ 3tha^{-1} + Furadan 5G@ 25 kgha^{-1}	19.13 ab	25.90 a	21.91 d	33.10
Tricho-compost-2 @ 3tha^{-1} + Furadan 5G@ 25 kgha^{-1}	20.67 a	27.70 a	27.70 a	32.83
Neem oil cake @ 500 kgha^{-1} + Furadan 5G @ 25 kgha^{-1}	19.73 ab	26.07 a	25.89 b	34.37
Control	16.07 c	17.40 c	18.97 e	29.60
LSD (P=0.05)	1.057	5.13	1.723	NS

Values within the same column with a common letter do not differ significantly (P=0.05).

Crop yield: Soil amendment with Tricho-compost or in combination of Tricho-compost and NOC with low dose of Furadan 5G gave appreciable increase in fruit number per plant and fruit yield per hectare in both the years (Table 4 and 5). Under control, the average fruit number per plant was 22.67 in 1st year and 28.00 in 2nd year. Fruit number per plant was increased from 31.33 to 38.67 in 1st and 35.33 to 41.33 in 2nd year due to different treatments (Table 4). In 1st year, integration of Tricho-compost-2 with Furadan 5G gave 41.38% higher number of fruits per plant over control followed by integration of NOC with Furadan 5G and Tricho-compost-1 with Furadan 5G treatments where number of fruits per plant was increased 41.00% and 40.33%, respectively compared to control. In 2nd year, all treatments with Tricho-compost, NOC and Furadan 5G caused significant increase in fruit number per plant over control. Integration of NOC with Furadan 5G and Tricho-compost-2 with Furadan 5G gave 32.25% and 31.71%, respectively higher fruit number per plant compared to control.

Integration of Tricho-compost-1 with Furadan 5G, Tricho-compost-2 and Tricho-compost-1 treatments gave comparatively lower fruit number per plant (Table 4). All these treatments were statistically similar where the least effective treatment was Furadan 5G.

Table 4. Efficacy of Tricho-composts, neem oil cake and Furadan 5G on the fruit number per plant of tomato in soil inoculated with *Meloidogyne incognita*

Treatments	Number of fruits plant^{-1}		Number of fruits increased over control (%)	
	1st year	2nd year	1st year	2nd year
Furadan 5G @ 45 kgha^{-1}	31.33 c	35.33 b	29.88	20.75
Tricho-compost-1 @ 3tha^{-1}	32.33 bc	38.33 ab	26.79	26.95
Tricho-compost-2 @ 3tha^{-1}	32.67 bc	39.67 ab	30.61	30.57
Tricho-compost-1 @ 3tha^{-1}+ Furadan 5G@ 25 kgha^{-1}	37.00 ab	40.33 ab	38.73	29.42
Tricho-compost-2 @3tha^{-1}+ Furadan 5G@ 25 kgha^{-1}	38.67 a	41.00 a	41.38	31.71
Neem oil cake @ 500 kgha^{-1}+ Furadan 5G @ 25 kgha^{-1}	36.67 ab	41.33 a	38.18	32.25
Control	22.67 d	28.00 c	-	-
LSD (P=0.05)	3.512	5.02	-	-

Values within the same column with a common letter do not differ significantly (P=0.05).

The lowest fruit yield of 40.0 t/ha was recorded from the control treatment during 1st year trial (Table 5). The yield ranged from 51.11 to 60.55 t/ha due to application of different treatments. The maximum fruit yield was obtained by integration of NOC with Furadan 5G, Tricho-compost-2 with Furadan 5G and Tricho-compost-1 with Furadan 5G where the fruit yield was 60.55, 60.55 and 57.78 t/ha, respectively. Integration of NOC, Tricho-compost-2 and Tricho-compost-1 with Furadan 5G gave 32.61, 30.34 and 30.07%, respectively higher yield compared to control. Efficacy of these three treatments for increasing fruit yield was statistically similar. Differences in fruit yield harvested from Furadan 5G treated plot and plots treated with Tricho-compost-1 and Tricho-compost-2 was not significant. In 2nd year, the average fruit yield was 49.60 t/ha under control and it ranged from 61.33 to 73.60 t/ha under other treated plots. The tomato yield was 32.61% higher compared to control due to application of Tricho-compost-2 with Furadan 5G. The yield was 30.34, 30.07, 28.74 and 27.91% higher due to integrated application of NOC with Furadan 5G, Tricho-compost-1 with Furadan 5G as well as singly application of Tricho-compost-2 and Tricho-compost-1, respectively compared to control. Furadan 5G alone was less effective to increase yield of tomato.

Table 5. Effect of soil treatment with Tricho-composts, organic amendment and nematicide on fruit yield of tomato in soil inoculated with *Meloidogyne incognita.*

Treatments	Fruit yield (t/ha)		Yield increase over control (%)	
	1st year	2nd year	1st year	2nd year
Furadan 5G @ 45 kgha^{-1}	51.11 b	61.33 b	21.74	19.19
Tricho-compost-1 @ 3tha^{-1}	52.22 b	68.80 a	23.40	27.91
Tricho-compost-2 @ 3tha^{-1}	53.33 b	69.60 a	24.99	28.74
Tricho-compost-1 @ 3tha^{-1}+ Furadan 5G@ 25 kgha^{-1}	57.78 a	70.93 a	30.77	30.07
Tricho-compost-2 @3tha^{-1}+ Furadan 5G@ 25 kgha^{-1}	60.55 a	73.60 a	33.94	32.61
Neem oil cake @ 500 kgha^{-1}+ Furadan 5G @ 25 kgha^{-1}	60.55 a	71.20 a	33.94	30.34
Control	40.00 c	49.60 c	-	-
LSD (P=0.05)	4.01	7.324	-	-

Values within the same column with a common letter do not differ significantly (P=0.05).

The present study revealed that integrated soil amending with Tricho-composts with Furadan 5G, neem oil cake and Furadan 5G drastically suppressed the root gall index value caused by root-knot nematode *M. incognita* and thereby improving plant growth parameters such as shoot length, shoot weight, root length, root weight and fruit yield of tomato compared to untreated control plot. Although soil amendment with Tricho-compost and Furadan 5G alone also reduced gall index values and improved plant growth to some extent, it was inferior in general. In the present study application of Trichoderma based bio-fungicide Tricho-compost @ 3 tha^{-1} or NOC @ 500 kg/ha with low dose of Furadan 5G @ 25 kgha^{-1} observed to be effective for reducing RKN disease of tomato. *Trichoderma* spp. can improve plant defense against diverse plant pathogens, including fungi, bacteria, viruses, and nematodes (Yaru *et al*., 2021; Akhter *et al*. 2021). The findings of the study are in agreement with the findings of (Singh 2013).. The study were also supported by the findings of (Singh and Mahanta 2013). The findings of the study are also in agreement with the findings of Kumar and Khanna (2006) who reported that combination of bio-control agents, chemical and vermi-compost (*T. harzianum* + *G. fasciculatum* +Carbosulfan ST + vermi-compost gave maximum reduction of nematode population of tomato in field. Kumari *et al*. (2020), Mukhtar (2018) and Devi *et al.* (2002) also supported the present findings that the soil application of fungal bio-control agents *T. viride*, *T. harzianum* and *T. asperellum* improving plant growth of tomato and significantly reduced reproduction of root-knot nematode in tomato. Many other researchers also confirmed previous findings, on the use of isolates of *Trichoderma* spp. for the management of root-knot nematodes of vegetable crops (Dababat *et al*., 2007; Sahebani and Hadavi, 2008; Affokpon *et al*., 2011; Faruk, 2022). 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; Faruk, 2020). Similar findings had also been reported by many other researchers that bio-control agents *Trichoderma* spp. and different oil cakes were effective in controlling root-knot nematode as well as increasing plant growth and yield of different crops (Yadav *et al.*, 2005; Javed, *et. al*., 2008; Sahebani and Hadavi, 2008; Singh *et al*., 2011; Lidia *et al*., 2014 and Nirosha *et al*., 2018).

Conclusion

From the present study it could be concluded that soil treated with either integration of Trichoderma based bio-fungicide Tricho-compost or neem oil cake with lower dose of Furadan 5G might be effective for reducing root-knot nematode disease, as well as increasing plant growth and fruit yield of tomato.

References

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

Afroz, M., M. Ashrafuzzaman, M. N. Ahmed, M. E. Ali, and M. R. Azim. 2008. Integrated Management of Major Fungal Diseases of Tomato. Int. J. Sustain. Crop Prod. **3(2):** 54-59

Akhter, M. S., K. S. Nakahara, and C. Masuta. 2021. Resistance induction based on the understanding of molecular interactions between plant viruses and host plants. *Virol J* 18, 176. https://doi.org/10.1186/s12985-021-01647-4

Akhter, M. S., A. M. Akanda, K. Kobayashi, R. K. Jain and B. Mandal. 2019. Plant virus diseases and their management in Bangladesh. Crop Prot., **118:** 57-65.

Akinpelu, D. A. 2001. Antimicrobial activity of *Anacardium occidentale* Bark. Fitoterapia. **72:** 286-287.

Aktar M. M., M. S. Akhter and A. M. Akanda. 2008. Impact of insecticides and organic oil spray on the growth and yield of tomato under TYLCV infected condition. Bangladesh Research Publication Journal. **1**(3): 199-205.

Anonymous. 1998. FAO production year books. Basic Data Units, Statistics Div. FAO Rome Italy, **52:** 124-125.

Bangladesh Bureau of Statistics (BBS). 2022. Yearbook of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh. p.347.

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

Devi, L.S., S. Richa and R. Sharma. 2002. Effect of *Trichoderma* spp. against root-knot nematode *Meloidgyne incognita* on tomato. Indian Journal of Nematology. **32(2):** 227-228.

Bari, M. A., Faruk, M. I., Rahman, M. L. and Ali, M. R. 2004. Effect of organic soil amendments and nematicide on root-knot nematode of brinjal. Bangladesh J. Plant Pathol. **20(1&2):** 27-30.

Faruk, M. I., Bari, M. A., Nahar, M. S., Rahman, M. A. and Hossain, M. M. 2001. Management of root knot nematode (*Meloidogyne*) of tomato with two organic amendments and a nematicide. Bangladesh J. Plant Pathol. **17(1&2):** 27-30.

Faruk, M. I. 2020. Efficacy of Organic Amendments and a Nematicide For the Management of Root-Knot Nematode *(Meloidogyne Incognita)* of Tomato. Universal Journal of Agricultural Research **8(2):** 25-32.

Faruk, M. I. 2022**.** Development of Biorational Management Package of Root Knot Nematode Disease of Country Bean. International Journal of Life Science Research Updates, **01(01):** 001–010.

Food and Agriculture Organization. 1997. FAO production years books. Basis Data Unit. Statistics Div. FAO Rome Italy, **21:** 125-127.

Hossain, M. E., M.J. Alam, M.A. Hakim, and A.S. Amanullah. 2010. An assessment of Physicochemical Properties of Some Tomato Genotypes and Varieties Grown At Rangpur. Bangladesh Res. Pub. J., **4(3):**135-243. Available from http://www.bdresearch publications. com/admin/journal/u pload/ 09180/ 09180.pdf.

Javed, N., S. E. 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. European Journal of Plant Pathology **120(1):**53-60.

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

Kumar, S. and A.S. Khanna. 2006. Role of *Trichoderma harzianum* and Neem Cake Separately and in Combination against Root-Knot Nematode on Tomato. Indian Journal of Nematology, **36(2):** 247-249.

Kumari, M., M. K. Sharma and B. L. Baheti. 2020. Biological control of root-knot nematode, *Meloidogyne incognita* infecting tomato (*Solanum lycopersicum*). Journal of Entomology and Zoology Studies, **8(1):** 35-39.

Lidia B., Marek S., Krysztof S., Jolanta L. and Malgorzata J. 2014. *Trichoderma* spp. application and prospects for use in organic farming and industry. Journal of Plant Protection Research **54(4):** 309-317.

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

Mukhtar, T. 2018. Management of Root-Knot Nematode, *Meloidogyne incognita*, in Tomato with Two *Trichoderma* Species. Pakistan Journal of Zoology. 2018; **50(4):**1589-1592.

Nirosha, A., S. Rajeshkanna and G. Mikunthan. 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.

Rao, M. S., Reddy, P. P. and Nagesh, M. 1997. Management of root knot nematode, *Meloidogyne incognita* on tomato by integration of *Trichoderma harzianum* with neem cake. Zeitschrift-fur-Pflanzenkrankheten-und Pflanzenschutz, **104(4):** 423-425.

Reddy, P. P., Nagesh, M. and Devappa, V. 1998. Management of *Meloidogyne incognita*on potato by integration of *Trichoderma harzianum*, *Glomus fasciculatum* and neem cake. Advances in IPM for horticultural crops. Proceedings of the First National Symposium on Pest Management in Horticultural Crops: environmental implications and thrust, India. 349-352.

Siddiqui, I. A., Haque, S. E. and Gaffar, A. 1999. Root dip treatment with *Pseudomonas aeruginosa* and *Trichoderma* spp. in controlling root knot complex in chilli. Pakistan J. Nematol. **17:** 65-75.

Sahebani N. and N. Hadavi. 2008. Biological control of the root-knot nematode *Meloidogyne javanica* by *Trichoderma harzianum*, *Soil Biology and Biochemistry* 40(8): 2016–2020, http://doi. org/10.1016/j.soilbio.2008.03.011 (accessed 17, Jun 2017).

Sassaer, J. N. 1989. Plant Prarasitic Nematodes: The Farmer's Hidden Enemy. North Carolina State University, Raleigh, North Carolina.

Sikora, R. A. and E. Fernandez. 2005. Nematode parasites of vegetables. In: Luc M., Sikora R.A., Bridge J., editors. Plant Parasitic Nematodes in Subtropical and Tropical Agriculture. Centre for Agriculture and Bioscience International: 319-339.

Singh, L. M. and B. Mahanta. 2013. Effect of carbosulfan, *Glomus fasciculatum, Trichoderma harzianum* and vermicompost alone and combination in management of *Meloidogyne incognita* on Green gram. Annals of Plant Protection Sciences. **21(1):**154- 156.

Singh, R. and U. Kumar. 2015. Assessment of nematode distribution and yield losses in vegetable crops of Western Uttar Pradesh in India. International Journal of Science and Research. **438:** 2812-2816.

Singh, S. 2013. Integrated approach for the management of the root-knot nematode, *Meloidogyne incognita*, on eggplant under field conditions. Nematology,**15:** 747-757.

Singh, S. and N. Mathur.2010. Biological control of root-knot nematode, *Meloidogyne incognita* infesting tomato. Biocontrol Science and Technology. **20:** 865-874.

Singh, S., A. B. Rai and R. K. Singh. 2011. Bio-management of root-knot disease of Chilli (*Capsicum annum*) caused by *Meloidogyne incognita*, Vegetable Science **38(1):** 63-67.

Tipu, M. M. H., R. Jahan, J. Rahman, M. I. Riad, M. M. Rahman and K. M. E. Nabi. 2021. Status of major diseases of brinjal and tomato in Charland of Jamalpur and Sherpur districts of Bangladesh. Plant Science Today. 8(1):161–165. https://doi.org/10.14719/pst.2021.8.1.988

Wachira, P. M., J. W. Kimenju, S. A. Okoth and R. K. Mibey. 2009. Stimulation of Nematode-Destroying Fungi by Organic Amendments Applied in Management of Plant Parasitic Nematode. Asian J. of Plant Sci., **8:** 153-159.

Yadav, Y. S., A. U. Siddiqui and P. Aruna. 2005. Management of root-knot nematode *Meloidogyne incognita* infesting gram through oil cakes. Journal of Phytological Research **18(2):** 263-264.

Yaru, Y., Q, Mao, Y. Wang, J. Zhao, Y. Fu, Z. Yang, X. Peng, M. Zhang, B. Bai, A. Liu, S. Chen and G. J. Ahammed.2021. *Trichoderma harzianum* induces resistance to root-knot nematodes by increasing secondary metabolite synthesis and defense-related enzyme activity in *Solanum lycopersicum* L. Biological Control **158(5):**104609.

Zeck, M. W. 1971. A rating scheme for field evaluation of root knot nematode infestation. Planzenschuta-Nacht, **24:** 141-144.