Agricultural Science
Volume 2, Issue 2 (2014), 21-30
ISSN 2291-4471 E-ISSN 2291-448X
Published by Science and Education Centre of North America

Assessment of Carrier Materials to Formulate *Trichoderma Harzianum* Bio-Fungicide for Controlling Foot and Root Rot Disease of Brinjal in Seed Bed

M. I. Faruk[1], M. L. Rahman[3], M. N. Islam[2], M. M. Rahman[1], and M. A. Rahman[4]

[1] Senior Scientific Officer, Plant Pathology Division, BARI, Bangladesh. mifaruk2012@yahoo.com

[2] Scientific Officer, Plant Pathology Division, BARI, Bangladesh. nazrulsau86@gmail.com

[3] Chief Scientific Officer, Training and Communication Wing, BARI, Bangladesh. lutfur@bari.gov.bd

[4] Chief Scientific Officer, Plant Pathology Division, BARI, Bangladesh. arahman_bari@yahoo.com

*Corresponding Author: Dr. Md. Iqbal Faruk, Senior Scientific Officer, Plant Pathology Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur-1701, Bangladesh. Tel. 88-02-9256405, Mobile. 88-01732587563, Fax. 88-02-9256405; E-mail. mifaruk2012@yahoo.com

DOI: 10.12735/as.v2i2p21

Abstract

Efficacy of eight different carrier materials and their combinations were tested to formulate a suitable *Trichoderma harzianum* based bio-fungicides for controlling foot and root rot diseases of brinjal caused by *Sclerotium rolfsii* in tray soil as well as seed bed soil under net house condition of Bangladesh Agricultural Research Institute (BARI). The results from a series of experiments revealed that four combination of carrier materials based *T. harzianum* bio-fungicides such as (1) wheat bran + rice bran, (2) wheat bran + mustard oil cake (MOC) + rice bran, (3) khesari bran + rice bran, and (4) khesari bran +MOC+ rice bran were suitable for controlling the soil borne foot and root rot disease (*S. rolfsii*) of brinjal in tray soil as well as seed bed soil conditions.

Keywords: *Trichoderma harzianum*, *Sclerotium rolfsii*, brinjal seedling

1. Introduction

Availability of quality food and nutrition are the major challenges to achieve healthy and prosperous Bangladesh like other developing countries of the world. Vegetable play a vital role in everyday diet in general. Among the vegetables, brinjal (eggplant) (*Solanum melongena* L.) is the major crop that has achieves tremendous popularity over the last century. It is grown usually in almost all countries of the world under field and greenhouse conditions. In Bangladesh brinjal is the second most important vegetable crop that is grown the whole year in any space available for crop cultivation. It is available in Bangladesh throughout the year providing vegetable to the consumers and steady financial assistance to the growers. FAOSTAT (2012) reported that the productivity of brinjal in Bangladesh is low (17.5 t/ha) as compared to Japan (32 t/ha), Italy (28.2 t/ha) and Turkey (30.2 t//ha). It is estimated that 10% of crops are lost due to plant diseases worldwide each year which can lead to considerable financial losses for the farmers of underdeveloped countries (Strange & Scott, 2005). Among the diseases germination failure and damping off are the major constraints in brinjal cultivation (Najar *et al.,* 2011). Especially *Sclerotium rolfsii* is the major pathogen for germination failure and damping off of brinjal. It is very difficult to control the soil borne pathogens, especially *S. rolfsii* through conventional method such as application of fungicides, cultural methods etc. On the other hand, application of chemical fungicides is expensive and also hazardous to health and environment (Brown & Hendrix 1980, Punja, Grogan, & Unruh, 1982). The beneficial microbes such as *Trichoderma harzianum* has been reported as a bio-control agent that effectively controlled the soil borne pathogens including *S. rolfsii* (Elad, Chet, & Katan, 1980; Roy, Das, & Bora, 1989). The native bio-control agents usually remain in the agricultural soil in low population density, so augmentation of their density to reach a higher stability level in soil through artificial inoculation is necessary for successful management of soil borne pathogens in brinjal seed bed. The major limitation is the lacking of appropriate mass culturing techniques of *T. harzianum* and inadequate information on the suitability of carrier materials (Harman & Taylor, 1990). There are some reports, where *T. harzianum* has been formulated as bio-fungicides in various carrier materials including wheat bran, rice bran, maize bran, sawdust (Das, Roy, & Bora, 1997); rice straw, chickpea bran, grass pea bran, rice course powder, black gram bran (Shamsuzzaman, Islam, & Hossain, 2003); cow dung, poultry manure, ground nut shell, black ash, coir waste, spent straw from mushroom bed, talc, vermiculite (Rettinassababady & Ramadoss, 2000); and jaggery, groundnut cake, neem cake, niger cake, pongamia (Jahagirdar, Siddaramaiah, & Narayanaswamy, 1998). All of these carrier materials are available in Bangladesh but their potentialities to use in the formulation of *T. harzianum* bio-fungicide have not yet been studied in the country. Therefore, the present study was undertaken to find out the effective local carrier materials to formulate the best medium for mass culturing of *T. harzianum* to be used as effective bio-fungicides against seedling disease (*S. rolfsii*) of brinjal under seed bed condition.

2. Materials and Methods

One experiment was conducted in the plastic tray and two experiments were conducted under seed bed conditions in the net house of Plant Pathology Division, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during the period 2008 to 2013 to find out the suitable carrier material for mass culturing of *T. harzianum* and thereby formulation of an effective bio-fungicides against soil borne seedling disease (*Sclerotium rolfsii*) of brinjal. A pure culture of bio-control agent *T. harzianum* (TM14) was used in these experiments. The fungus *T. harzianum* (TM14) was grown on Potato Dextrose Agar (PDA) medium which was used later as an inoculum of bio-fungicide. The substrates used in this study were Rice husk, Rice bran, Wheat bran, Maize bran, Khesari bran, Soybean bran, Saw dust and Mustard Oilcake (MOC). The requisite amount of material for each substrate was mixed thoroughly in 1000 ml Erlenmeyer flask and sterilized in an autoclave at 121^0C for 15 minutes and finally cooled down to make it ready for inoculation. The sterilized substrate was inoculated with 5 mm diameter mycelial disc of five-day old culture of *T. harzianum* grown on PDA and then incubated at room temperature (25±2 ^{0}C) for 15 days. After incubation the colonized substrates were removed from the flasks and air dried and finally preserved in refrigerator at 10 ^{0}C for 10 days. Besides, the pathogenic fungi *S. rolfsii* was multiplied on sterilized barley grains in 1000 ml Erlenmeyer flask at temperature of 25±2 ^{0}C for 15 days.

One experiment was conducted in the plastic tray to screen out the suitable substrates to formulate the *T. harzianum* bio-fungicide against the brinjal seedling disease (*S. rolfsii*). In this experiment pathogenic fungus *S. rolfsii* and *T. harzianum* bio-fungicide were used at the rate of (@) 20 g/kg soil and seeds of BARI Brinjal 2 (Raton) were sown in the tray soil @100 seeds per tray. The tray experiment was laid out in completely randomized design (CRD) with six replications. In control treatment the soil was only infected with *S. rolfsii* and the experiment was set in the natural environmental condition and necessary intercultural operations were done as per recommendation of the crop (Anon., 2007).

Two experiments were conducted to evaluate the individual and combined effect of *T. harzianum* bio-fungicides in seed bed under net house condition. In these seed bed experiments the colonized barley grains were incorporated in the seed bed soils @100 g/m^2 soil. Inoculated seed bed soil was allowed to multiply the pathogen *S. rolfsii* for 10 days with proper soil moisture. The inoculum of *T. harzianum,* colonized on different substrates, were incorporated in the seed bed soils @100 g/m^2 soil and kept for 7 days with proper soil moisture for establishment of *T. harzianum* in the soils. The seeds of BARI Brinjal 2 (Raton) were sown in the seed bed @ 200 seeds per treatment. In control treatment the soil was only infected with *S. rolfsii.* The experiment was laid out in completely randomized design (CRD) with four replications and necessary intercultural operations were done as per recommendation of the crop (Anon., 2007). .

Data were collected on percent seed germination, seedling mortality, shoot height, shoot weight, root length and root weight of brinjal seedlings. The percent data were converted into arcsine transformation values before statistical analysis. The data were analyzed statistically by using the MSTATC program. The treatment effects were compared by applying the least significant difference (LSD) test.

3. Results and Discussions

3.1 Screening of Carrier Materials for *Trichoderma Harzianum* Bio-Fungicides

Table 1. Effect of different carrier based on T. harzianum bio-fungicides on the emergence and mortality of brinjal seedling in Sclerotium rolfsii inoculated soils in the plastic tray

Name of carrier materials for *T. harzianum*	Seedling emergence (%)	Pre-emergence mortality (%)	Post-emergence mortality (%)	Total mortality (%)	Mortality reduction (%) over control	Total healthy seedling (%)
Rice husk	61.00	39.00	9.73 (15.89 b)	48.73	37.72	51.27
Rice bran	78.00	22.00	0.00 (0.37 c)	22.00	64.45	78.00
Wheat bran	82.00	18.00	4.89 (9.05 bc)	22.89	63.56	77.11
Maize bran	73.00	27.00	5.01 (9.40 bc)	32.01	54.44	67.99
Khesari bran	70.00	30.00	5.76 (10.09 bc)	35.76	50.69	64.24
Soybean bran	67.00	33.00	0.00 (0.37 c)	33.00	53.45	67.00
Saw dust	41.00	59.00	22.22 (40.51 a)	81.22	5.23	18.78
Untreated Control	38.00	62.00	24.45 (41.76 a)	86.45	0.00	13.55

Note: Values in a column having same letter did not differ significantly (p=0.05) by LSD; values within the parentheses were the Arcsine Transformed value

Efficacy of the bio-agent *Trichoderma harzianun* against *Sclerotium rolfsii* causing foot and root rot disease of brinjal seedlings was tested in the plastic tray where the soil was artificially inoculated with the pathogen *Sclerotium rolfsii* and then treated with the different carrier based on *T. harzianum* bio-fungicides. Percent seedling emergence as well as seedling mortality was varied among the carrier based *T. harzianum* bio-fungicides (Table 1). In the case of *S. rolfsii* inoculated soil, the seedling emergence of brinjal was significantly higher and ranged from 61% (rice husk) to 82% (wheat bran) due to the carrier based on *T. harzianum* bio-fungicide treatments whereas untreated control tray gave lower seedling emergence (38%). Saw dust based on *T. harzianum* bio-fungicide also gave lower seedling emergence which is statistically similar to untreated control. The amount of both pre-emergence as well as post-emergence seedling mortality of brinjal varied among the carrier based on *T. harzianum* bio-fungicides resulting total seedling mortality of 22.00 to 48.73%, while higher total seedling mortality of 81.22% and 86.46% was recorded from the saw dust and untreated control trays, respectively. Thus soil treatment with *T. harzianum* reduced seedling mortality of 5.23 - 64.45% as compared to untreated control (Table 1). The result showed that *T. harzianum* treated tray soil except saw dust soil gave higher amount of healthy seedlings (51.27- 77.11%) while saw dust and untreated control tray soil produced only 18.78% and 12% healthy seedling, respectively in *S. rolfsii* inoculated soil. The overall performance of the bio-fungicides with respect to reduction of brinjal seedling disease under *S. rolfsii* inoculated condition indicated that better results were obtained if carrier based on *T. harzianum* bio-fungicides were rice bran, wheat bran, maize bran and soybean bran (Table 1).

3.2 Efficacy of Carrier Material Based *T. Harzianum* Bio-Fungicides and Provax

Seedling emergence of brinjal was increased significantly (p=0.05) due to soil treatment with bio-fungicides (*T. harzianum*) in the *S. rolfsii* inoculated soil of seed bed. The carriers based on T. harzianum bio-fungicides were statistically similar in respect of seedling emergence but differ from Provax and untreated control (Table 2). The effect of carrier based on *T. harzianum* bio-fungicides on reduction of seedling mortality viz. pre-emergence, post-emergence and total mortality were encouraging and also followed the similar trends. Maximum reduction of brinjal seedling mortality (33.95%) over control was achieved with the application of *T. harzianum* bio-fungicide of Khesari bran followed by wheat bran, rice bran and maize bran while Provax gave the minimum mortality reduction (13.88%).

Table 2. Effect of selected carrier based on *T. harzianum* bio-fungicides on the emergence and mortality of brinjal seedling in *Sclerotium rolfsii* inoculated soils in seed bed

Name of carrier materials for *T. harzianum*	Seedling emergence (%)	Pre-emergence seedling mortality (%)	Post-emergence seedling mortality (%)	Total seedling mortality (%)	Mortality reduction (%) over control
Khesari bran	60.25 (51.24 a)	39.75 (39.05 c)	9.23 (17.43 b)	48.98	33.95
Wheat bran	60.00 (50.79 ab)	40.00 (39.21 c)	9.82 (18.09 b)	49.82	33.11
Maize bran	55.25 (48.03 ab)	44.75 (41.97 bc)	10.27 (18.49 b)	55.02	27.91
Rice bran	57.25 (49.19 ab)	42.75 (40.81 bc)	10.66 (18.97 b)	53.41	29.52
Provax	52.75 (46.87 b)	47.25 (43.42 b)	21.80 (27.82a)	69.05	13.88
Untreated Control	44.75 (41.97 c)	55.25 (48.02 a)	27.68 (31.68 a)	82.93	-
LSD (p=0.05)	3.77	3.713	4.479	-	-

Note: Values in a column having same letter did not differ significantly (p=0.05) by LSD; values within the parentheses were the Arcsine Transformed values

Shoot length and shoot weight of brinjal seedlings were increased significantly (p=0.05) by the carrier based on *T. harzianum* bio-fungicides khesari bran, wheat bran, maize bran and rice bran comparing to Provax and untreated control in the *S. rolfsii* inoculated seed bed soil (Table 3). The effects of carrier based *T. harzianum* bio-fungicide on the root growth of brinjal seedlings were significantly better over Provax as well as untreated control. The overall root growth of brinjal seedling was found better due to *T. harzianum* bio-fungicide in the carrier of khesari bran, wheat bran and rice bran (Table 3).

Table 3. Effect of selected carrier based on *T. harzianum* bio-fungicides on the vegetative growth of brinjal seedling in *Sclerotium rolfsii* inoculated soils in seed bed

Name of subtracts	Shoot length (cm)	Shoot weight (g/plant)	Root length (cm)	Root weight (g/plant)
Khesarie bran	21.75 a	2.54 a	11.15 a	0.33 a
Wheat bran	19.98 b	2.33 a	10.02 ab	0.23 b
Maize bran	14.48 c	1.58 b	10.55 ab	0.19 b
Rice bran	13.95 c	1.60 b	10.30 ab	0.21 b
Provax	11.68 d	1.32 bc	9.33 b	0.19 b
Untreated Control	9.43 e	1.11 c	7.93 c	0.12 c
LSD (p=0.05)	0.9168	0.2779	1.223	0.047

Note: Values in a column having same letter did not differ significantly (p=0.05) by LSD

3.3 Combination of Carrier Material Based on *T. Harzianum* Bio-Fungicides and Provax

Table 4. Effect of carrier based on *Trichoderma harzianum* bio-fungicides and Provax on suppression of brinjal seedling disease caused by *Sclerotium rolfsii* in seed bed

Name of carrier materials for *T. harzianum*	Seedling emergence (%)	Pre-emergence seedling mortality (%)	Post-emergence seedling mortality (%)	Total seedling mortality (%)	Seedling mortality reduction (%) over control
Wheat bran	51.33 (45.77 bc)	48.67	7.67 (16.07 ab)	56.34	14.66
Khesari bran	54.33 (47.49 ab)	45.67	6.67 (13.34 c)	52.34	18.66
Rice bran	55.67 (48.26 ab)	44.33	7.67 (16.07 ab)	52.00	19.00
Wheat bran + Rice bran	55.67 (48.26 ab)	44.33	6.67 (14.51 c)	51.00	20.00
Wheat bran + MOC+ Rice bran	55.33 (48.06 ab)	44.67	7.33 (15.70 b)	52.00	19.00
Khesari bran + Rice bran	59.33 (50.39 a)	40.67	6.67 (14.90 bc)	47.34	23.33
Khesari bran +MOC + Rice bran	55.33 (48.06 ab)	44.67	6.67 (14.95 bc)	51.34	19.66
Rice bran + MOC	53.33 (46.92 ab)	46.67	7.67 (16.07 ab)	54.34	16.66
Wheat bran + Khesari bran + MOC	54.00 (47.30 ab)	46.00	6.67 (14.95 bc)	52.67	18.33
Wheat bran + Khesari bran+ Rice bran + MOC	53.67 (47.11 ab)	46.33	6.67 (14.95 bc)	53.00	18.00
Seed treatment with Provax	59.33 (50.39 a)	40.67	6.33 (13.27 c)	46.00	25.00
Untreated Control	45.67 (42.51 c)	54.33	16.67 (24.09 a)	71.00	-

Note: Values in a column having same letter did not differ significantly (p=0.05) by LSD; values within the parentheses were the Arcsine Transformed value

The seedling emergence of brinjal in *S. rolfsii* inoculated soils in seed bed was sharply enhanced by the application of different carrier based on *T. harzianum* bio-fungicides and Provax (Table 4). The individual as well as combined application of *T. harzianum* bio-fungicides was found superior in seedling emergence as compared to the untreated control. Seedling emergence of brinjal ranged from 51.33% to 59.33% due to the application of different bio-fungicide in seed bed. The trend was reverse in respect of pre-emergence, post-emergence and total mortality of brinjal seedlings in the *S. rolfsii* inoculated seed bed soil. Application of Provax gave maximum reduction of seedling mortality (25.00%) over control followed by combined used of khesari bran + rice bran (23.33%) and wheat bran + rice bran (20.00%) based bio-fungicide and the minimum seedling mortality was observed in case of wheat bran based bio-fungicide (14.66%). The findings indicated that combined use of khesari bran + rice bran and wheat bran + rice bran based bio-fungicides was equally effective as Provax in controlling seedling mortality of brinjal (Table 4).

Shoot and root growth of brinjal seedling in *S. rolfsii* inoculated seed bed soil was significantly augmented as compare to untreated control by the application of different carrier based *T. harzianum* bio-fungicides and the Provax (Table 5). The shoot length of brinjal seedlings was ranged from 16.93 cm to 18.17 cm due to bio-fungicide and minimum shoot length (12.53 cm) was obtained from the control bed. Shoot weight of brinjal seedlings were also followed the similar trend of results due to the bio-fungicides and Provax. Root length enhanced up to 7.47 cm by khesari bran + rice bran based bio-fungicide followed by Provax (7.23 cm) and the shortest root was found in untreated control of the *S. rolfsii* inoculated seed bed soil (Table 5). Root weight did not significantly differ among all the treatments including untreated control (Table 5). The results revealed that shoot and root growth of brinjal seedlings in the *T. harzianum* bio-fungicides treated seed bed was superior to untreated control.

Table 5. Effect of carrier based on *Trichoderma harzianum* bio-fungicides and Provax on the vegetative growth of brinjal seedling in *Sclerotium rolfsii* inoculated seed bed

Name of carrier materials for *T. harzianum*	Shoot length (cm)	Shoot weight (g/plant)	Root length (cm)	Root weight (g/plant)
Wheat bran	18.17 a	4.49 a	6.67 abc	0.20
Khesari bran	17.37 a	4.66 a	6.93 ab	0.20
Rice bran	17.77 a	4.51 a	7.13 ab	0.19
Wheat bran + Rice bran	16.93 a	4.41 a	7.23 ab	0.19
Wheat bran + MOC+ Rice bran	17.97 a	4.49 a	6.40 bc	0.18
Khesari bran + Rice bran	18.00 a	4.55 a	7.47 a	0.19
Khesari bran +MOC+ Rice bran	18.10 a	4.63 a	6.67 abc	0.18
Rice bran + MOC	17.13 a	4.41 a	6.63 abc	0.19
Wheat bran + Khesari bran +MOC	18.17 a	4.59 a	7.10 ab	0.19
Wheat bran + Khesari bran + Rice bran + MOC	17.17 a	4.30 a	7.20 ab	0.21
Seed treatment with Provax	17.90 a	4.29 a	6.50 bc	0.20
Untreated Control	12.53 b	3.33 b	5.90 c	0.20
LSD (p=0.05)	1.47	0.53	0.79	NS

Note: Values in a column having same letter did not differ significantly (P=0.05) by LSD

The emergence of brinjal seedlings in *S. rolfsii* inoculated seed bed soil was significantly (p=0.05) increased due to application of different *T. harzianum* based bio-fungicide (Table 6). Maximum seedling emergence (82.33%) was recorded from the seed bed treated with Rice bran + MOC based bio-fungicide of followed by khesari bran MOC bran + rice bran (80.33) and wheat bran + rice bran (80.00%) while the minimum (60.00%) was recorded from the untreated control. Post-emergence mortality of brinjal seedling was the reverse trend, where untreated control bed showed the highest post-emergence mortality (38.67%) and khesari bran + MOC bran + rice bran based bio-fungicide gave the lowest (10.67%) mortality. Besides, seedling mortality was 12.67% in case of seed treating chemical Provax (Table 6). Shoot length (8.17 - 9.73 cm) and shoot weight (4.68 - 6.70 g/plant) of brinjal seedling were also enhanced by the combined used of *T. harzianum* bio-fungicides over individual bio-fungicide while Provax gave poorer shoot growth. The results indicated that the combined application of *T. harzianum* bio-fungicides were better for root growth of brinjal seedlings in the inoculated bed soil over untreated control (Table 6).

Table 6. Effect of carrier based on *Trichoderma harzianum* bio-fungicides on reduction of seedling disease (*Sclerotium rolfsii*) and vegetative growth of brinjal in seed bed

Name of carrier materials for *T. harzianum*	Seedling emergence (%)	Post-emergence seedling mortality (%)	Shoot length (cm)	Shoot weight (g/plant)	Root length (cm)	Root weight (g/plant)
Wheat bran	72.33 (58.41 b)	11.67 (20.78 b)	7.40 bc	5.26 b	5.80 bc	0.41 bc
Khesari bran	78.33 (62.29 ab)	11.33 (19.94 b)	7.25 cd	5.14 b	6.33 ab	0.42 bc
Rice bran	72.00 (58.07 b)	13.33 (21.39 b)	7.10 cd	4.91 bc	5.20 cd	0.37 e
Wheat bran + Rice bran	80.00 (63.46 ab)	12.33 (19.67 b)	9.73 a	6.70 a	6.27 ab	0.40 bc
Wheat bran + MOC+ Rice bran	77.00 (61.49 ab)	12.67 (20.56 b)	8.13 bc	5.13 b	6.27 ab	0.41 bc
Khesari bran + Rice bran	77.33 (61.61 ab)	11.33 (20.84 b)	9.33 ab	6.35 a	6.53 ab	0.47 a
Khesari bran +MOC+ Rice bran	80.33 (63.69 ab)	10.67 (19.67 b)	9.37 ab	6.18 a	6.53 ab	0.42 bc
Rice bran + MOC	82.67 (66.07 a)	12.33 (19.04 b)	9.17 ab	6.50 a	6.87 a	0.41 bc
Wheat bran + Khesari bran + MOC	77.33 (61.77 ab)	11.67 (20.19 b)	8.17 abc	4.68 bc	6.67 ab	0.43 b
Wheat bran + Khesari bran+ Rice bran + MOC	72.67 (58.49 b)	12.67 (19.94 b)	9.47 ab	6.57 a	6.93 a	0.42 bc
Seed treatment with Provax	73.67 (59.13 b)	12.67 (20.78 b)	7.00 cd	4.28 c	4.27 de	0.38 de
Untreated Control	60.00 (50.78 c)	38.67 (38.44 a)	6.30 d	3.35 d	3.57 e	0.33 f
LSD (p=0.05)	5.632	2.613	1.387	0.617	0.982	0.023

Note: Values in a column having same letter did not differ significantly (P=0.05) by LSD; values within the parentheses were the Arcsine Transformed values

The overall effects of the carrier based *T. harzianum* bio-fungicides on the emergence, mortality, growth and development of brinjal seedlings under *S. rolfsii* inoculated soils as revealed from the results of these experiments indicated that four different combination of carriers viz. (1) wheat bran + rice bran, (2) wheat bran + MOC+ rice bran, (3) khesari bran + rice bran, and (4) khesari bran +MOC+ rice bran were seemed to be superior for brinjal seedling disease (*S. rolfsii*) management in seed bed condition.

The finding of the present study was in accordance with the reports of many other researchers and some of them were cited in this script. Soil amendment with formulated *Trichoderma* proved to be effective in controlling *Sclerotium rolfsii* the causal agent for seedling disease of many crops and many researchers reported antagonistic activity of *Trichoderma* isolates against plant pathogens especially against fungal pathogens such as *Rhizoctonia solani, Fusarium oxysporum* and *Sclerotium rolfsii* (Lo, Nelson, & Harman, 1996; Tran, 1998; Bari, Rahman, & Mian, 2000; Shamsuzzaman *et al.*, 2003; Ngo, Vu, and Tran, 2006; Shalini, Narayan, & Kotasthane, 2006). Harman, Howell, Viterbo, Chet, and Lorito (2004) reported that application of *Trichoderma* spp. as biocontrol agent influenced seed germination, seedling vigor as well as increased growth of shoot, root and productivity of brinjal. The formulated *T. harzianum* grown on peat soil based black bran was found to be effective in controlling some of the nursery diseases like damping off, tip over and seedling blight of egg plant and also promoted seed germination (Meah, Islam, & Islam, 2004). Sangeetha, Jeyarajan and Panicker (1993) reported that rice bran yielded 35% higher seed germination in brinjal and wheat as well as rice bran as the best substrate for the formulation of *Trichoderma.* The disease incidence of brinjal, water melon and cotton was reported to be reduced considerably by the application of *T. harzianum* (Sivan & Chet, 1986). Ghaffar (1987) reported that the *in-vitro* growth of *Sclerotium oryzae* and formation of sclerotia was drastically inhibited by the presence of *T. harzianum*. Similarly, Jee and Kim (1987) reported that *T. harzianum* was the best *in-vitro* antagonist soil borne pathogens. Begum, Rahman, and Hossain (1999) reported that *T. harzianum* treated seeds of black gram gave 86.7% to 100% reduction of foot and root rot disease caused by *Sclerotium rolfsii* over the control. Tehroni and Nazari (2004) observed *T. harzianum* as an effective remedy against *Phytophthora* damping-off of cucumber. Shoresh *et al*. (2005) stated that *Trichoderma* spp. are effective bio-control agents for a number of soil borne plant pathogens and induced a potentate state in the plant enabling it to be more resistant to subsequent pathogen infection.

Acknowledgement

The authors thankfully acknowledged BAS-USDA to provide financial support for the pieces of research and Bangladesh Agricultural Research Institute, Gazipur for providing logistic support. Special thanks to Dr. T. K. Dey, former Chief Scientific Officer Plant Pathology Division, BARI for his fruitful discussions. Thanks go to Mr. Md. Abdur Razzak and Mr. Zamil Akter (Scientific Assistant) for their sincere assistance in this research work.

References

[1] Anonymous (2007). *Research Report on Horticultural Crops (2006-07)* (pp. 93). Horticulture Research Centre, BARI, Joydebpur, Gazipu.

[2] Bari, M.A., Rahman, M. L., & Mian, I. H. (2000). Bilogical control of potato black scurf disease through fungal antagonist. *Bangladesh Journal of Plant Pathology*, *16*(1/ 2), 5-7.

[3] Begum, M. M., Rahman, M. A., & Hossain, I. (1999). Antagonistic effect of *Trichoderma harzianum* on *Sclerotium rolfsii* in food legumes. *Journal of Bio-Science, 7*, 81-88.

[4] Brown, E. A., & Hendrix, F. F. (1980). Distribution and control of *S. rolfsii* on apple. *Plant Disease, 64*(2), 205-206.

[5] Das, B. C., Roy, S. K., & Bora, L. C. (1997). Mass multiplication of *Trichoderma* species on different media. *Journal of the Agricultural Science Society of North-East India, 10*(1), 95-100.

[6] Elad, Y., Chet, I., & Katan, J. (1980). *Trichoderma harzianum*: A biocontrol agent effective against *Sclerotium rolfsii* and *Rhizoctonia solani*. *Phytopathology, 70*(2), 119-121.

[7] FAOSTAT. (2012). *Food and Agriculture Organization of United Nations statistical database*. Retrieved from http://faostat.fao.org/.

[8] Ghaffar, A. (1987). *Soil mangement practices for the control of sclerotial fungi* (pp.14). Department of Botany, University of Karachi, Pakistan.

[9] Harman, G. E., Howell, C. R., Viterbo, A., Chet, I., & Lorito, M. (2004). *Trichoderma* species opportunistic, avirulent plant symbionts. *Nature Reviews Microbiology, 2*(1), 43-56.

[10] Harman, G. E., & Taylor, A. G. (1990). Development of an effective biological seed treatment system. In D. Hornby (Ed.), *Biological control of soil-borne plant pathogens* (pp. 415-426). Wallingford, UK: C.A.B. International.

[11] Jee, H. J., & Kim, H. K. (1987). Isolation, identification and antagonisms of rhizospheric antagonists to cucumber wilt pathogen, *Fusarium oxysporum* f.sp. *cucumerinum* Owen. *Korean Journal of Plant Pathology, 3*(3), 187-197.

[12] Lo, C. T., Nelson, E. B., & Harman, G. E. (1996). Biological control of turfgrass diseases with a rhizosphere competent strains *Trichoderma harzianum*. *Plant Disease*, *80*(7), 736-741.

[13] Meah, M. B., Islam, M. R., & Islam, M. M. (2004). *Development of an integrated approach for management of Phomopsis Blight and Fruit rot of eggplant in Bangladesh* (pp.62). Annual Research Report. Department of Plant Pathology, BAU, Mymensingh, Bangladesh.

[14] Ngo, B. H., Vu, D. N., & Tran, D. Q. (2006). Analyze antagonist effects of *Trichoderma* spp. for controlling southern stem rot caused by *Sclerotium rolfsii* on peanut. *Plant Protection, 1*, 12-14.

[15] Punja, Z. K., Grogan, R. G., & Unruh, T. (1982). Comparative control of *S. rolfsii* on golf grass in Northern Calfornia with fungicides, inorganic salt and *Trichoderma* spp. *Plant Disease, 66*, 1125-1128.

[16] Rettinassababady, C., & Ramadoss, N. (2000). Effect of different substrates on the growth and sporulation of *Trichoderma viride* native isolates. *Agricultural Science Digest, 20*(3), 150-152.

[17] Roy, S. J., Das, B. S., & Bora, L. C. (1989). Non pestcidal management of damping-off of cabbage caused by *Rhizoctonia solani* kuehn. *Journal of the Agricultural Science Society of North-East India, 11*(2), 127-130.

[18] Sangeetha, P., Jeyarajan, R., & Panicker, S, (1993). Mass multiplication of bio-control agent *Trichoderma spp.* Indian Journal of Mycology and Plant Pathology, 23(3): 328-330.

[19] Shalini, K. P., Narayan, L., & Kotasthane, A. S. (2006). Genetic relatedness among *Trichoderma* isolates inhibiting a pathogenic fungi *Rhizoctonia solani*, *African Journal of Biotechnology, 5*(8), 580-584.

[20] Jahagirdar, S., Siddaramaiah, A. L., & Narayanaswamy, H. (1998). Screening of substrates of mass multiplication of *Trichoderma viride. Karnataka Journal of Agricultural Sciences, 11*(1), 233-236.

[21] Shamsuzzaman, Islam, S. M. A., & Hossain, I. (2003). *Trichoderma* culture and germination of sweet gourd seed. *Bangladesh Journal of Seed Science & Technology, 7*(1/ 2), 91-95.

[22] Shoresh, M., Yedidia, I., & Chet, I. (2005). Involvement of Jasmonic Acid/Ethylene Signaling Pathway in the Systemic Resistance Induced in Cucumber by *Trichoderma asperellum* $T_{203.}$ Phytopathology. 95(1): 76-84.

[23] Sivan, A., & Chet, I. (1986). Biological control of *Fusarium* spp. in cotton, wheat and muskmelon by *Trichoderma harzianum*. *Journal of Phytopathology, 116*(1), 39-47.

[24] Strange, R. N., & Scott, P. R. (2005). Plant disease: a threat to global food security. *Annual Review of Phytopathology, 43*, 83-116.

[25] Tehroni, A. S., & Nazari, S. (2004). Antagonistic effects of *Trichoderma harzianum* on *Phytophthora derchsleri*, the causal agent of cucumber damping off. *Acta horticulturae, 635*, 137-139.

[26] Tran, T. T. (1998). Antagonistic effectiveness of *Trichoderma* against plant fungal pathogens. *Plant Protection, 4*, 35-38.

Copyrights