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Full Length Research Paper

Development of eco-friendly management packages against foot and root rot and wilt diseases of chickpea

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The experiments were conducted in the fields of Plant Pathology Division, Bangladesh Agricultural Research Institute, Gazipur during 2013-14, 2014-15 and 2015-16 cropping years. The formulated *Trichoderma harzianum* (Tricho-compost for soil amendment and spore suspension for seed treatment) and organic soil amendment poultry refuse either singly or in combination with chemical fungicide Provax 200 WP were tested against soil-borne pathogens, *Sclerotium rolfsii* and *Fusarium oxysporum* f. sp*. ciceri* of chickpea causing foot and root rot and wilts diseases. The organic soil amendment poultry refuse was incorporated in the two weeks before seed sowing of chickpea and allowed to decompose properly where Tricho-composts were incorporated in the soil seven days before seed sowing. Seeds were treated with *Trichoderma* spore suspension and Provax at the time of seed sowing. From this study it was revealed that soil amendment with Tricho-compost or integration poultry refuse with seed treatment by Provax 200 WP performed as the best treatments in reducing seedling disease and increasing plant growth and yield of chickpea which were significantly differed from the other treatments including control. Soil amendment with poultry manure alone showed better performance against the disease and seed treatments with chemical fungicide Provax 200 WP and *Trichoderma* spores suspension which effect at per. All of the treatments reduced seedling mortality and increased plant growth and yield of chickpea.

Keyword: *Trichoderma harzianum*, *Sclerotium rolfsii*, *Fusarium oxysporum* f. sp*. ciceri*, *Cicer arietinum*, Chickpea

INTRODUCTION

Chickpea (*Cicer arietinum* L.) belongs to the family Fabaceae is an important legume crop in the semi-arid tropics of the world and it is the third most important pulse crop in the world including Bangladesh (Vishwadhar and Gurha 1998; Hasanuzzaman *et al.* 2007). Chickpea (*Cicer arietinum* L.) is a vital source of plant derived edible protein in many countries. It also has advantages in the management of soil fertility, particularly in dry lands and the semiarid tropics. In Bangladesh, the production of chickpea is decreasing every year and also the yield of chickpea is very low as compared to other chickpea growing countries due to many biotic and abiotic factors (Anonymous 1989 and 2010). The chickpea crop is attacked by 172 pathogens (67 fungi, 22 viruses, 3 bacteria, 80 nematodes and mycoplasma) from all over the world (Nene *et al.* 1996). *Sclerotium rolfsii* Sacc. and *Fusarium oxysporum* f. sp*. ciceri* are two major fungal pathogens causing diseases called foot and root rot and wilt which contributing 55-95% seedling mortality of chickpea (Azhar *et. al.* 2006). These fungi can attack the crop during any time from seedling to flowering stage and are comparatively more destructive at the seedling stage. The diseases may cause 100% seedling mortality in monoculture under favorable weather conditions for disease development (Begum, 2003). Theses Fungi are soil borne pathogens commonly occurs in the tropics and sub-tropics regions of the world

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causing diseases of many crops and also a facultative saprophyte (Aycock 1966). It can survive in the soil up to six years in the absence of susceptible host (Haware *et al.* 1978). Considering the nature of damage and survival ability of the pathogen, use of resistant varieties is the only economical and practical solution. But most of the resistant varieties have been found to be susceptible after some years because of breakdown of their resistance due to evolution of variability in the pathogen. Chemical fungicides are only the way to minimize the severity of these diseases but major limitation is the requirement of a large amount of chemicals which are expensive and hazardous to human health as well as environment (Gerhardson 2002). Therefore, environment and user friendly biological control measure or integrated management strategies may be an alternative method of controlling these pathogens in large fields. *Trichoderma* may be used as an ecofriendly bio-control agent in this regard. *Trichoderma* spp. have been widely used as antagonistic fungal agents against seed and soil borne diseases of different crops, namely legumes and vegetables as well as plant growth enhancers (Sultana *et al*. 2001, Hossain and Naznin 2005a; Ozbay and Newman 2004; Shoresh *et al*. 2005; Verma *et al*. 2007). *T. harzianum* is commercially used as preventive measure for several soil borne plant pathogenic fungi (Harman 2006; Shalini *et al.* 2006). For mass production of *Trichoderma,* many researchers have successfully used cost effective substrates like wheat bran, rice bran, maize bran, sawdust (Das *et al*. 1997); rice straw, chickpea bran, grass pea bran, rice course powder, black gram bran (Shamsuzzaman *et al*. 2003); cow dung, poultry manure, ground nut shell, black ash, coir waste, spent straw from mushroom bed, talc, vermiculite (Rettinassababady and Ramadoss 2000), sewage sludge compost (Cotxarrera *et. al*. 2002). So, mass production of *T. harzianum* on comparatively cheap, stable and easily available substrate is essential. On the other hands the use of organic amendments such as animal manure, green manure (the incorporation of crop residues into the soil), composts and peats has been proposed, both for conventional and biological systems of agriculture, to improve soil structure and fertility (Magid *et al*. 2001; Conklin *et al*. 2002; Cavigelli and Thien 2003) and decrease the incidence of disease caused by soil borne pathogens (Litterick *et al*. 2004; Noble and Coventry, 2005). Several studies have shown that organic amendments can be very effective in controlling diseases caused by pathogens such as *Fusarium* spp. (Szczech 1999), *Phytophthora* spp. (Szczech and Smolin´ska, 2001), *Pythium* spp. (McKellar and Nelson 2003; Veeken *et al.* 2005), *Rhizoctonia solani* (Diab *et al*. 2003), *Sclerotinia* spp. (Boulter *et al*. 2002), *Sclerotium* spp. (Coventry *et al.* 2005). Therefore, the present investigation aimed to control foot and root rot and wilt diseases of chickpea under field conditions with low environmental impact; by using different control measures viz.: Tricho-composts, organic soil amendments and seed treatment with chemical fungicides singly or as an integrated disease management strategy.

MATERIAL AND METHODS

The performance of poultry refuse, Tricho-inocula (*T. harhianum*), Tricho-composts and Provax 200 WP in controlling foot and root rot and wilt diseases of chickpea caused by *Sclerotium rolfsii* and *Fusarium oxysporum* was investigated in the field of plant pathology Division of Bangladesh Agricultural Research Institute at three cropping seasons during 2014-15, 2015-16 and 2016-17. Previously, seventy two isolates of *T. harzianum* were obtained from different location of Bangladesh and their efficacy was tested against different soil borne pathogens including *S. rolfsii* and *F. oxysporum* in the laboratory. Few isolates of *T. harzianum* including TM11 were found more vigorous to suppress the soil borne pathogens including *S. rolfsii* and *F. oxysporum*. A pure culture of *T. harzianum* (TM11) was grown in potato dextrose agar (PDA) medium which was used to formulate the substrates.

Tricho-compost preparation: Isolated *T. harzianum* (TM11) was initially multiplied on substrate containing a mixture of rice bran, wheat bran and mustard oilcake to obtain a formulated *T. harzianum*. The formulated *T. harzianum* was used for mass multiplication in two different mixtures of cow dung based compost materials. One of those composts contained cow dung and rice bran and the other contained a mixture of cow dung, rice bran and poultry manure. The formulated *Trichoderma* was added in between two layers of compost materials and kept for 45-50 days maintaining the moisture content approximately 60-70% for rapid multiplication of *T. harzianum* in the compost materials. Based on compost materials used in composting these composts were designated as Tricho-compost-1 and Tricho-compost-2.

Pathogenic fungal inocula preparation: The pure cultures of the pathogenic fungi *S. rolfsii* was prepared on potato dextrose agar (PDA) medium. The inoculum of *S. rolfsii* and *F. oxysporum* was multiplied separately on a mixture of wheat bran, khesari bran and mustard oilcake (MOC).

Seed treatment: The *T. harzianum* was cultured in potato dextrose agar (PDA) potato dextrose broth (PDB) media and the spores were harvested from 10 days old culture separately. The seeds of chickpea (var. BARI Chola 5) were treated with the spore suspension of *T harzianum* maintaining the approximate spore concentration of $1x10^8$/ml. Similarly another set of seeds were also treated with seed treating chemical Provax 200 WP @ 2.5 g/kg seeds at the time of seed sowing.

Table 1. Effect of Tricho-composts and poultry refuse on the seedling emergence of chickpea

Treatment	Average seedling emergence (%)			Pre-emergence seedling mortality (%)		
	2013-14	2014-15	2015-16	2013-14	2014-15	2015-16
Seed treatment with Provax	95.00 (78.10 a)	81.67 a (65.19)	81.67 a (64.71)	5.00	18.33	18.33
Seed treatment with *Trichoderma* inocula	95.00 (78.10 a)	81.67 a (65.00)	78.67 a (62.51)	5.00	18.33	21.33
Soil amendments with Tricho-compost-1	95.67 (82.96 a)	76.67 a (61.46)	82.33 a (65.16)	4.33	23.33	17.67
Soil amendments with Tricho-compost-2	95.67 (78.76 a)	76.67 a (61.14)	82.67 a (65.49)	4.33	23.33	17.33
Soil amendments with poultry refuse	92.33 (77.54 a)	80.00 a (63.55)	80.67 a (63.96)	7.67	20.00	19.33
Poultry refuse + Seed treatment with Provax	96.00 (79.35 a)	81.67 a (64.71)	84.67 a (67.01)	4.00	18.33	15.33
Control	74.67 (60.01 b)	48.33 b (44.01)	55.67 b (48.26)	25.33	51.67	44.33

Values in a column having same letter did not differ significantly (P=0.05) by LSD; values within the parenthesis is the Arcsin Transformed value

Field experiment: The field trials were conducted in the fields of Plant Pathology Division, BARI, Gazipur during 2014-15, 2015-16 and 2016-17 cropping years. There were seven treatments such as (i) Seed treatment with Provax 200 WP @ 2.5 gkg^{-1} (ii) Seed treatment with *Trichoderma* spore suspension @ $1X10^8$ $sporeml^{-1}$ (iii) Soil amendment with Tricho-compost-1 @ 3 tha^{-1} (iv) Soil amendment with Tricho-compost-2 @3 tha^{-1} (v) Soil amendment with poultry refuse @5 tha^{-1} (vi) Seed treatment with Provax 200 WP .@ 2.5 gkg^{-1} + Soil amendment with poultry refuse @3 tha^{-1} and (vii) Untreated control. The field experiments were laid out in randomized complete block design (RCBD) with 3 replications. The unit plot size was 3.5 m x 3 m. The field soil was inoculated with *S. rolfsii* and *F. oxysporum* colonized substrate consisting of khesari bran, wheat bran and mustard oilcake @ $100g/m^2$ of soil and allowed the pathogen establishment in the soil for 7 days before seed sowing. The field soil was again treated with the Tricho-composts and kept for 5 days. Where requisite quantity of partially decomposed poultry refuse were incorporated with the soil 2 weeks before seed sowing of chickpea and allowed to decompose properly. The seeds of chickpea var. BARI Chola 5 were sown @ 45 kg ha^{-1} in the experimental plots maintaining row to row distance of 40 cm. Proper intercultural operations were done for better growth of chickpea in the field. No plant protecting chemicals (insecticides or fungicides) were applied in the field.

Determination of foot and root rot disease: The experimental plots were inspected routinely to observe the foot and root rot and wilt disease of chickpea in the field. In case of complexity to identify the disease, symptoms-bearing plants were collected from the field using polythene bag and brought to the laboratory for further analysis. From the infected plants, the pathogens were isolated following tissue planting methods (Baxter *et al*. 1999). After incubation, the fungi that grew over potato dextrose agar (PDA) were purified by the hyphal tip culture method. The isolated fungi were identified as *S. rolfsii* and *F. oxysporum* according to reference mycology books and manuals (Barnett and Hunter 1972; Booth 1971). The pure cultures of the fungi were preserved in PDA slants at 4°C in the refrigerator as stock culture for future use.

Data collection and analysis: Data on different parameters viz., germination, post-emergence seedling mortality, shoot length, root length, shoot weight, root weight, yield of chickpea were taken. Data were analysis by using MSTATC program following ANOVA. Treatment means were computed using least significant difference (LSD) test.

RESULTS

Seedling emergence and pre-emergence mortality

Every year, seedling emergence of chickpea was significantly increased over control by soil amendment with Tricho-composts, poultry refuse and seed treatment with Tricho-inocula and Provax 200 WP (Table 1). In the 1st year, seedling emergence varied from 92.33-95.67% among the treatments where control (74.67%) gave comparatively low emergence of chickpea seedling (Table-1). Similarly, soil amendment with Tricho-composts, poultry refuse and seed treatment with Tricho-inocula and Provax 200 WP gave higher seedling emergence in the 2nd year and 3rd year trials ranged from 76.67 to 81.67% and 78.67 to 84.67%, respectively compared to untreated contro

Table 2. Effect of Tricho-composts and poultry refuse on the reduction of seedling disease of chickpea

Treatment	Average post-emergence seedling mortality (%)			Reduction of seedling mortality than control (%)		
	2013-14	2014-15	2015-16	2013-14	2014-15	2015-16
Seed treatment with Provax	5.00 bc (12.89)	12.67 b (20.67)	12.67 d (20.84)	76.19	69.59	70.76
Seed treatment with *Trichoderma* inocula	9.33 b (17.12)	14.33 b (22.11)	18.00 b (25.08)	55.57	65.61	58.46
Soil amendments with Tricho-compost-1	3.00 c (9.97)	12.00 b (20.20)	14.33 cd (22.24)	85.71	71.20	66.93
Soil amendments with Tricho-compost-2	4.33 bc (11.76)	11.67 b (19.88)	12.33 d (20.54)	79.38	71.99	71.54
Soil amendments with poultry refuse	6.00 bc (14.05)	11.67 b (19.88)	15.67 bc (23.31)	71.43	71.99	63.84
Poultry refuse + Seed treatment with Provax	5.00 bc (12.89)	11.67 b (19.82)	8.67 e (17.12)	76.19	71.99	79.99
Control	21.00 a (27.01)	41.67 a (40.17)	43.33 a (41.75`)	-	-	-

Values in a column having same letter did not differ significantly (P=0.05) by LSD; values within the parenthesis is the Arcsin Transformed value.

which gave much lower seedling emergence of 48.33% in 2nd year and 55.67% in 3rd year, respectively.

On the contrary, soil and seed treatment with the *Trichoderma* bio-control agents, organic soil amendment and chemical fungicide Provax caused significant reduction in pre-emergence seedling mortality of chickpea compared to control. The range of pre-emergence seedling mortality was 4.33- 7.67%, 18.33-23.33% in second year and 17.33-21.33% in third year. The corresponding mortality under control was 25.33, 51.67 and 44.33% in first year, second year and third year, respectively. Efficacy of all treatments to reduce the pre-emergence mortality was not significantly different (Table 1).

Post-emergence seedling mortality due to foot and root rot and wilts diseases

Post-emergence seedling mortality due to foot and root rot and wilt diseases of chickpea was sharply reduced by soil amendment with Tricho-composts, poultry refuse and seed treatment with Tricho-inocula and Provax 200 WP and also by the integration poultry refuse and Provax 200 WP during three cropping years (Table 2). The highest seedling mortality 21.00%, 41.67% and 43.33% in the first year, second year and third year, respectively was recorded in the untreated control plot. Lower seedling mortality range from 3.00-9.33% in the first year, 11.67-14.33% in the second year and 8.67-18.00% in the third year was recorded due to the soil amendment with Tricho-composts, poultry refuse, soil amendment with poultry refuse + seed treatment with Provax 200 WP and seed treatment with Tricho-inocula and Provax 200 WP. The reduction of seedling mortality was from 55.57-79.38% in first year, 65.61-71.99% in second year and 58.46-79.99% in third years due to various treatments as compared to untreated control.

Shoot growth

Shoot growth such as shoot length and shoot weight of chickpea were significantly influenced by different treatments in all the years (Table 3). The lowest shoot length 15.67 cm, 26.50 cm and 28.67 cm in the first year, second year and third year, respectively was recoded under control plot. In first year, the shoot length of chickpea under different treatments was significantly higher range from 21.20 to 23.67 cm compared to control (Table 3). In the second year, soil amendment with Tricho-compost-2 and poultry refuse + seed treatment with Provax gave the higher shoot length 41.40 cm and 40.47 cm, respectively followed by soil amendment with Tricho-compost-1, seed treatment with Provax, soil amendment with poultry refuse and seed treatment with *Trichoderma* inocula where the shoot length was 37.97 cm, 36.30 cm, 35.83 cm and 34.20 cm, respectively (Table 3). During third year trial, soil amendment with poultry refuse + seed treatment with Provax gave the highest shoot length of 47.53 cm followed by soil amendment with *T. harzianum* based Tricho-compost-2, Tricho-compost-1, poultry refuse alone and seed treatment with Provax 200 WP. The lowest shoot height was recorded from untreated control in all the years.

The shoot weight of chickpea under control was 14.33, 15.77 and 19.23 gplant^{-1} in first, second and third year, respectively. Soil amendment and seed treatment with poultry refuse, *T. harzianum* based Tricho-composts, *Trichoderma* inocula and chemical fungicide Provax increased the parameter to 15.33-16.80, 21.33-27.70 and 25.37-34.60 gplant^{-1} in first, second and third year,

Table 3. Effect of Tricho-composts and poultry refuse on the shoot growth of chickpea

Treatment	Average shoot length (cm)			Average shoot weight (gplant^{-1})		
	2013-14	2014-15	2015-16	2013-14	2014-15	2015-16
Seed treatment with Provax	21.80 a	36.30 b	42.87 cd	15.80 ab	23.10 bc	26.70 c
Seed treatment with *Trichoderma* inocula	21.20 a	34.20 b	40.83 d	15.33 bc	21.33 c	25.37 c
Soil amendments with Tricho-compost-1	22.07 a	37.97 b	44.73 bc	15.93 ab	26.40 ab	29.73 b
Soil amendments with Tricho-compost-2	22.80 a	41.40 a	46.20 ab	16.87 a	27.70 a	31.50 b
Soil amendments with poultry refuse	21.93 a	35.83 b	43.43 c	15.87 ab	21.97 c	29.37 b
Poultry refuse + Seed treatment with Provax	23.67 a	40.47 a	47.53 a	16.80 a	27.00 a	34.60 a
Control	15.67 b	26.50 c	28.67 e	14.33 c	15.77 d	19.23 d

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

Table 4. Effect of Tricho-composts and poultry refuse on the root growth of chickpea

Treatment	Average root length (cm)			Average root weight (gplant^{-1})		
	2013-14	2014-15	2015-16	2013-14	2014-15	2015-16
Seed treatment with Provax	12.93 ab	12.10 a	15.67 c	1.58 ab	2.20	2.40 c
Seed treatment with *Trichoderma* inocula	10.33 bc	11.97 a	14.13 d	1.64a	2.20	2.10 d
Soil amendments with Tricho-compost-1	12.53 ab	13.20 a	16.67 ab	1.60 a	2.47	2.68 b
Soil amendments with Tricho-compost-2	13.60 a	12.27 a	15.93 bc	1.70 a	2.33	2.62 b
Soil amendments with poultry refuse	12.27 ab	12.67 a	15.57 c	1.69 a	2.23	2.35 c
Poultry refuse + Seed treatment with Provax	12.07 ab	11.80 a	17.40 a	1.77 a	2.40	2.98 a
Control	8.47 c	8.33 b	10.53 e	1.41 b	1.73	1.53 e

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

respectively. Every year, the increase in the shoot weight of chickpea seedling due to different treatments was significant compared to control. Among the treatment soil amendment with poultry refuse + seed treatment with Provax gave the highest shoot weight in all the years followed by soil amendment with *T. harzianum* based Tricho-compost-2, Tricho-compost-1, poultry refuse alone and seed treatment with Provax 200 WP. The lowest shoot weight was recoded from control (Table 3).

Root growth

Every year, the root length of chickpea was significantly lower in the control compared to soil amendments with poultry refuse, *Trichodema* based Tricho-composts and Provax treatments. In the 1st year, 2nd year and 3rd year, the root length of chickpea ranged 10.33-13.60, 11.80-13.20 and 15.57-17.40 cm under different treatments where it was 8.47, 8.33 and 10.53 cm in control, respectively (Table 4). In the 1st year, 2nd year and 3rd year, the ranges of root weight were 1.58-1.77, 2.20-2.47 and 2.10-2.98 gplant^{-1}, respectively in the different treatments. The lowest root weight 1.41, 1.73 and 1.53 gplant^{-1} in the 1st year, 2nd year and 3rd year, respectively was recorded from control (Table 4).

Yield of chickpea

Every year, the yield of chickpea was significantly increased by soil amendments with poultry refuse + seed treatment with Provax 200, soil amendment *T. harzianum* based Tricho-composts, poultry refuse, seed treatment with Provax 200 WP and *Trichoderma* inocula (Table 5). The lowest yield of chickpea was recorded under control by 1202, 1328 and 1028 kgha^{-1} in the first year, second year and third year, respectively (Table 5). The yield of chickpea was increased significantly ranging from 1473-1790, 1595-1992 and 1541-1889 kgha^{-1} $^{-1}$ in the first year, second year and third year, respectively due to different treatments. Among the treatments, soil amendment with poultry + seed treatment with Provax 200 gave the

Table 5. Effect of Tricho-composts and poultry refuse on the yield of chickpea

Treatment	Yield (kgha^{-1})			Yield higher than control (%)		
	2013-14	2014-15	2015-16	2013-14	2014-15	2015-16
Seed treatment with Provax	1511 b	1672 b	1667cd	20.45	20.57	38.33
Seed treatment with *Trichoderma* inocula	1473 b	1595 b	1541 e	18.40	16.74	33.29
Soil amendments with Tricho-compost-1	1638 ab	1878 a	1750 bc	26.62	29.28	41.26
Soil amendments with Tricho-compost-2	1768 a	1945 a	1778 b	32.85	31.72	42.18
Soil amendments with poultry refuse	1581 ab	1628 b	1625 de	23.97	18.43	36.74
Poultry refuse + Seed treatment with Provax	1790 a	1992 a	1889 a	32.01	33.33	45.58
Control	1202 c	1328 c	1028 f	-	-	-

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

highest yield by1790, 1992 and 1889 kgha^{-1} in the 1st year, 2nd year and 3rd year, respectively followed by soil amendment with Tricho-compost-2, Tricho-compost-1, soil amendment with poultry refuse and seed treatment with Provax 200 where the yield was 1768, 1638, 1581 and 1511 kgha^{-1} in the 1st year, 1945, 1878, 1628 and 1672 kgha^{-1} in the 2nd year and 1778, 1750, 1625 and 1667 kgha^{-1} in the 3rd year, respectively. Seed treatment with *Trichoderma* inocula gave lower yield by 1473, 1595 and 1541 kgha^{-1} in the first year, second year and third year, respectively compared to other treatments but significantly higher yield than control. Results showed that the yield of chickpea was higher ranging from 18.40-32.01%, 16.74-33.33% and 33.29-45.58% in the 1st year, 2nd year and 3rd year, respectively compared to control due to various treatments (Table 5). Soil amendment with poultry refuse + seed treatment with Provax 200 gave the maximum 32.85%, 33.33% and 45.58% higher yield in the 1st year, 2nd year and 3rd year, respectively compared to control followed by Tricho-compost-2, Tricho-compost-1, soil amendment with poultry refuse and seed treatment with Provax 200 where the yield was 32.01%, 26.62%, 23.97% and 20.57% in the first year, 31.72%, 29.28%, 18.43% and 20.57% in the 2nd year, 42.18%, 42.26%, 36.74% and 38.33% in the 3rd year, respectively compared to control. But seed treatment with *Trichoderma* inocula gave only 18.40%, 16.74% and 33.29% higher yield in the 1st year, 2nd year and 3rd year, respectively compared to control.

DISCUSSION

The saprophytic fungus *Trichoderma* are naturally available in almost all agricultural soils and have been found as potential bio-control agent against plant pathogenic fungi causing diseases of many crops, particularly many soil borne pathogens (Freeman *et al*. 2004; Ashrafizadeh *et al*. 2005; Dubey *et al*. 2007). The soil borne plant pathogenic fungi *S. rolfsii* and *Fusarium* causing seedling mortality and wilt diseases of many crops and are the widespread problem for crop production. The management of these diseases with use of chemicals is hardly successful. The management plant diseases especially soil borne diseases by using bio-control agents *Trichoderma* spp. and organic soil amendments had long been studied (Tran 1998; Abawi and Widmer 2000; Akhtar and Malik 2000) but its potentiality in Bangladesh agriculture was yet been explored. Therefore, soil treatment with Tricho-composts, poultry refuse, seed treatment with *Trichoderma* spore suspension and Provax 200 WP, integration of poultry manure with Provax 200 WP were evaluated against foot & root rot and wilt diseases of chickpea in the field during three consecutive years. Results came out from the studies showed that integration of poultry manure with Provax 200 WP and soil treatment with Tricho-compost suppressed foot and root rot and wilt diseases caused by soil borne pathogens *S. rolfsii* and *F. oxysporum* f. sp. *ciceri* , increasing plant growth and yield of chickpea. The use of organic amendments such as animal manure, green manure (the incorporation of crop residues into the soil), composts and peats has been proposed, both for conventional and biological systems of agriculture, to improve soil structure and fertility (Magid *et al*. 2001; Conklin *et al*. 2002; Cavigelli and Thien 2003), and decrease the incidence of disease caused by soil borne pathogens (Litterick *et al*. 2004; Noble and Coventry 2005). Uzun (2004) and Younis (2005) also reported that *Trichoderma* isolates potentially reduced the disease caused by phtyopathogenic fungi such as *R. solani, F. oxysporum* and *S. rolfsii.*

Synthetic media are costly for mass production of *T*. *harzianum*. Therefore, organic substrates such as rice bran, wheat bran and their integration with mustard oilcake were used for mass production of *T*. *harzianum* and it is useful for large scale production of *T*. *harzianum* based compost for soil amendment. Rini and Sulochana (2007) reported that locally available organic media viz., coir pith, cow dung, poultry manure and neem cake are the excellent sources of nutrition for antagonistic fungi like *T. harzianum* and *T. viride* Besides, cow dung and neem cake mixture was reported as a recommended practice for field multiplication of *Trichoderma* (KAU 2002). On the other hands there is an increasing tendency in crop protection to integrate different methods of control. Combining methods of control is at the heart of integrated pest management, and may result in either additive or synergistic effect. The expected benefit of this strategy is improved and sustainable control of pests and diseases. The goal of IPM methods is to employ measures that are more efficient, healthier, and more environmentally friendly in the long run, and to reduce the amount of pesticides used (Katan 1999). The results from the present study clearly indicated that both integration of poultry manure with chemical fungicide Provax 200 WP and Tricho-compost having biological control agent *T. harzianum* provided effective protection measure against seedling diseases of chickpea and also caused plant growth promotion with higher grain yield of chickpea.

The use of bio-control agents such as *Trichoderma* spp and organic soil amendment in in combination with other control methods, e.g. chemical fungicides, steam disinfection and soil heating or solarization has provided an effective control of soil borne pathogens and have the potential to improve soil properties, plant health and yield (Omar *et al.* 2006; Klein *et al.* 2007; Gamliel and Katan 2009; Slusarski *et al*. 2012). Several workers also reported that the antagonistic activity of different *Trichoderma* isolates against various phtyopathogenic fungi such as *R. solani, F. oxysporum* and *S. rolfsii* and enhanced plant growth parameter such as shoot height, root length, and shoot weight (Hossain and Shamsuzzaman 2003; Hossain and Naznin 2005b; Shaban and El-Bramawy 2011). Ristaino (2002) also reported that organic soil amendments are effective against soil borne pathogen and enhanced the yield of the crop.

Therefore, it may be concluded that integration of poultry manure with chemical fungicide Provax 200 WP or soil amendment with Tricho-composts is the best treatment for management of seedling diseases and increasing plant growth and yield of chickpea followed by soil amendment with poultry manure alone, seed treatment with Provax 200 WP and *T. harzianum* spore suspension.

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