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POPULATION DYNAMICS OF *TRICHODERMA HARZIANUM* IN BIO-FORTIFIED COMPOST AGAINST SOIL-BORNE POTATO DISEASES

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Abstract

Soil-borne diseases pose significant challenges to global potato cultivation, resulting in yield losses and economic implications. Utilizing biological control agents offers a sustainable and environmentally and friendly approach to manage these diseases. Before implementing the experiment in the field, a series of in-vitro tests were conducted to select a virulent isolate of the tested pathogens and an effective antagonistic isolate of *Trichoderma harzianum*. In the pathogenicity test, isolate RS-1 of *Rhizoctonia solani* and isolate SR-8 of *Sclerotium rolfsii* exhibited the highest virulence against two pathogens in potato variety 'Cardinal' in regard to seedling mortality (44.44-88.88%). During *in vitro* screening, *T. harzianum* isolate Tri 7 displayed the greatest ability to inhibit the mycelium growth of all tested pathogens. In the field trial, the highest seedling mortality (69.06%) was observed in T_2 (Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii*). However, the highest seedling mortality (86.94%) was reduced by treatment T_7 (Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +500g wheat grain colonized with *Trichoderma* fortified poultry compost). Treatment T_7 also recorded the lowest incidences of stem canker (7.83%) and stem rot (8.64%), whereas the highest disease incidences occurred in the T_2 treatment plot. Notably, treatment T_7 gave the highest yield of 30.94 tons/ha, while the control plot T_2 yielded the lowest at 12.17 tons/ha. Initially, *Trichoderma* population was minimal prior to the application of Trichoderma-fortified compost. However, populations gradually increased over time, peaking at 3 months across all treatments except the control, where no *Trichoderma* was applied. However, a decline in *T. harzianum* population was noted one month after potato harvesting. This approach offers a potential solution for managing potato soil-borne diseases in a sustainable and environmentally friendly manner.

Keywords: Bio-fortified compost, soil-borne pathogens, yield, *Rhizoctonia solani*, *Sclerotium rolfsii*.

Introduction

Plant disease management and improvement of yields using traditional methods, such as chemical pesticides, herbicides, or fertilizer, are not eco-friendly, as they consist of various aromatic groups or methylated and ethylated substances, which to a large extent, have extreme effects on the environment. Long-term use of chemical pesticides contaminates water, causing atmosphere pollution, and sometimes leaves harmful residues, which can develop fungicide resistance races of the pathogen. To overcome these problems, researchers look for alternative options,

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such as using bio-control agents (BCA) for disease control either alone or in an integrated approach with other chemicals for eco-friendly and sustainable disease control methods.

Currently, *Trichoderma* has gained maximum attention as a biocontrol agent since it is effective against a large number of soil-borne plant pathogenic fungi without adversely affecting beneficial microbes like *Rhizobium* and is capable of promoting the growth of certain crops (Ramanujam *et al*., 2010). *Trichoderma* strains have been employed successfully as biological control agents of numerous plant diseases, despite being one of the world's most studied and known microorganisms (Verma *et al*., 2007). *Trichoderma* species are able to establish easily in any rhizosphere soil and can persist for a longer period on plant propagules up to several months (Elad *et al*., 1980). According to Ethur *et al*. (2008), *Trichoderma* species settle better in soils when they contain vegetable remains and other forms of organic matter. This is the potentiality of *Trichoderma* to be a strong and effective bio-control agent because the establishment of a sufficient population on the target site is the primary limiting factor for the utilization of any bio-control agent.

Organic manures are well established as useful in fertilizer of plants due to their beneficial effect on the physical, chemical and biological characteristics of the soil. It also reduces the chemicals needed for pest control, besides improving soil physical properties in the long run. Chicken litter has long been used as a soil amendment to provide nutrients for plant growth, increase organic matter in the soil, improve microbial populations, and control pathogens. Poultry compost fortified with *T. harzianum* was successfully applied in controlling different soil-borne diseases of tomato, (Rahman, 2013; Salam, 2017), Bush bean (Liton *et al*., 2019), Chilli (Simi *et al*., 2019; Roy *et al*., 2022), lentil (Das *et al*., 2019). These studies standardized the mixing ratio of poultry compost and the dose of *Trichoderma* fortified compost.

Population dynamics of pathogens is the study of how the size and structure of populations respond to the forces that act on them (Shaw, 2006). Establishing an antagonist in soil or substrate and its subsequent proliferation may be essential in the biological control of pathogens. The appropriate dose of *Trichoderma*-fortified compost and the sustainability of viable propagule/inoculum of *Trichoderma* spp. after application in the field are critical factors for the success of biological control of soil-borne diseases. Until now, the appropriate dose of *Trichoderma* fortified compost for controlling major soil-borne potato diseases is not standardized in Bangladesh. To study the population dynamics and sustainability of *Trichoderma* in soil, the potato variety "Cardinal" was selected as the model crop to control different soil soil-borne pathogens, including *R. solani* and *S. rolfsii*. Rubayet and Bhuiyan (2016) succeeded in controlling stem canker and black scurf caused by *R. solani* and stem rot caused by *S. rolfsii* by applying *T. harzianum* as a component of integrated disease management. Data on population density/ proliferation of *Trichoderma* spp. in the soil after application is not available for sustainable production.

Considering the above-mentioned facts, the study has been undertaken to select the appropriate dose of *Trichoderma*-fortified poultry compost for controlling major soil-borne diseases of potato, to assess the potential for growth improvement and increased potato yield through the application of Trichoderma fortified poultry compost and to measure the population density of *Trichoderma-harzianum-in*-field soil of potato after application of *Trichoderma* fortified poultry compost.

Materials and Methods

Collection, isolation of *T. harzianum* and potato pathogens

A total of 15 *T. harzianum* isolates were used, of which nine isolates were isolated from the soil of different crop fields (Mian, 1995) and six isolates were collected from the Plant Disease Diagnostic Clinic of BSMRAU campus. *Trichoderma harzianum* isolates and test pathogen isolates were collected and isolated from individual samples following the soil dilution plate technique (Mian, 1995). These fungi were grown on Potato Dextrose Agar (PDA) medium and identified by following the standard key (Barneet & Hunter, 1972). The pure culture of pathogen isolates and *T. harzianum* were preserved using PDA slants at 4 ***ºC in*** a refrigerator as stock cultures for future use.

Screening of *T. harzianum* isolates against virulent isolates of the selected pathogens

Inoculum of the test pathogens *R. solani* and *S. rolfsii* was prepared following the standard procedure (Rubayet and Bhuiyan, 2016) to select virulent isolates through pathogenicity tests in pot culture against potato variety "Cardinal". *In vitro* tests were conducted to evaluate the antagonistic effect of 15 isolates of *T. harzianum* against *S. rolfsii* and *R. solani* on PDA (Potato Dextrose Agar) medium by dual plate culture technique (Dhingra and Sinclair, 1985). A distinct inhibition zone was measured after five days of incubation and the percent inhibition of radial growth of *S. rolfsii* and *R. solani* was calculated following the formula:

Where, X = Mycelial development of pathogen in the absence of *T. harzianum* (control) and

B= Mycelial development of pathogen in the presence of *Trichoderma harzianum*

Preparation of *T. harzianum* fortified compost with poultry refuges

A highly antagonistic isolate Tri 7 of *T. harzianum* was selected on the basis of in-vitro screening test and inculum of antagonist was prepared by colonizing wheat grain with *Trichoderma* isolates following the procedure as described by Salam (2017). A total of five compost pits were prepared where each compost pit contained 40 kg poultry manure and after 30 days of decomposition, wheat grain colonized *Trichoderma* inoculum at 3.2, 4.8, 6.4, 8 kg, i.e., 8, 12, 16 and 20% were mixed in four different compost pits and one poultry compost pit without wheat grain colonized *Trichoderma* inoculum was maintained as control treatment. Compost pits were allowed for 90 days for decomposition and degradation (James, 2008).

Treatments of the experiments

Two separate experiments were conducted in the same field following similar treatments with two different pathogens *R. solani* and *S. rolfsii*. Treatments for both experiments were T_1 (Control 1) = Only fresh seeds without any amendment, T_2 (Control 2) = Fresh seeds+

Soil inoculated with *R. solani* and *S. rolfsii*, T_3= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +only poultry refuse, T_4= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +200g wheat grain colonized *T. harzianum* fortified poultry compost, T_5= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +300g wheat grain colonized *Trichoderma* fortified poultry compost, T_6= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +400g wheat grain colonized *T. harizianum* fortified poultry compost, T_7= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +500g wheat grain colonized *T. harzianum* fortified poultry compost.

Preparation of the Field Experiments

The experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications maintaining three blocks, plot size was 3 m × 2 m, row-to-row distance 50 cm, and distance between block to block was 1.0 m. Seven different treatments were allotted randomly to eight-unit plots in each block. *Trichoderma*-fortified compost was applied after seven days of *R. solani* and *S. rolfsii* inoculation following standard procedure (Das *et al.*, 2019).

Observation of disease development and growth and yield

Potato plants were observed regularly after sowing to record the incidence of pre- and post-emergence seedling mortality and different diseases at different stages of plant growth, both on plant parts & tubers. Diseases were recorded up to the harvest of potato. Observations were made by selecting five plants randomly from each plot. Disease severity was rated on a 0-4 scale and crop diseases were expressed as percentages following the standard formula (Salam, 2017). Growth-promoting factors were recorded and the total yield was weighed treatment-wise after harvest.

Measurement of population density of *T. harzianum* at a different time of intervals

Population Density of *T. harzianum* was measured at one-month intervals for a total of five times throughout the crop duration. At first, soil samples were collected from the plots one month before applying *Trichoderma* fortified compost. A selective medium Rose Bengal Agar (RBA) as described by Martin (1950) was used to assess the population density of *T. harzianum*. The population density of *Trichoderma* was calculated by serial dilution plate count method. Approximately 20 ml of appropriately cooled molten RBA and gently rotated clockwise to let the suspension distribute uniformly in the medium. The plates were incubated at room temperature for 7 days and colonies were counted on a colony counter. Population was estimated and expressed as colony forming units (cfu) per gram of soil.

Data analysis

Two separate experiments were conducted twice following Randomize Complete Block Design. Statistically, data were analyzed using the Statistix 10 computer program and the treatment means were compared following Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Pathogenicity assessment of the tested isolates

Among the five isolates of *R. solani* isolate

RS-1 and the same number of isolates of *S. rolfsii* isolate SR-8 were found as the highly virulent to potato. However, the total seedling mortality of potato by the tested isolates ranged from 44.44 to 88.88%. These two isolates were selected for field inoculation.

Screening of *T. harzianum* isolates against virulent isolates of potato pathogen

A total of 15 selected isolates of *T. harzianum* were tested against the virulent isolate of *R. solani (*RS-1) and *S. rolfsii* (SR-8) on the PDA medium by dual culture technique to observe the antagonistic effect of *T. harzianum*. All the isolates of *T. harzianum* had antagonistic effects against *R. solani* and *S. rolfsii* with different degrees of inhibition. The isolates of *T. harzianum* Tri 7 appeared superior, causing 77.92% inhibition of the radial growth of *R. solani* was 83.33% inhibition of the radial growth of *S. rolfsii* (Fig. 1). This isolate was selected to prepare *Trichoderma*-fortified poultry compost for managing stem canker, black scurf, and stem rot diseases of potato. *Trichoderma* species are well-known for their ability to produce antifungal metabolites, enzymes, and other bioactive compounds that can suppress the growth and development

Fig. 1. *In vitro* antagonistic effect of *T. harzianum* isolate Tri 7 against *R. solani* and *S. rolfsii.* A) Dual culture plate of isolate Tri 7 against *R. solani.* B) Dual culture plate of isolate Tri 7 against *S. rolfsii.*

of various plant pathogens. In this case, the selected *Trichoderma* isolate likely exhibits a strong antagonistic effect against the pathogens responsible for stem canker, black scurf, and stem rot diseases in potato. The results of the screening study are in agreement with Ahmed *et al*. (2019), Das *et al.* (2019), Rahman *et al*. (2020), and Rubayet *et al*. (2020).

Seedling mortality caused by *R. solani* and *S. rolfsii*

Different doses of *Trichoderma* fortified poultry compost were used to manage two major soil-borne potato diseases under field conditions. Pre and post-emergence seedling mortality of potato caused by *R. solani* and *S. rolfsii* were recorded up to four weeks of plant growth. In all the treatments, seedling mortality was significantly reduced compared to the treatment $T_{2,}$ where fresh seeds were sown in the soil inoculated with *R. solani* and *S. rolfsii* (control 2) without any amendment. Significantly the highest total seedling mortality was observed in the treatment T_2 (78.13%), followed by T_1 (40.63%) and T_3 (31.25%) in the case of *R. solani* and S. *rolfsii* inoculated field (Table 1). In all the treatments of both the *R. solani* and S. *rolfsii* inoculated field, the highest reduction of total mortality was found in $T_{7,}$ where 500g wheat grain colonized *Trichoderma* fortified poultry compost was used, followed by $T_{6,}$ where 400g wheat grain colonized *Trichoderma* fortified poultry compost was used. *R. solani* and *S. rolfsii* are two common soil-borne pathogens that can cause pre- and post-emergence mortality in various vegetable crops, including potato. These pathogens can infect the seeds, seedlings, and young plants, leading to damping-off, root rot, and stem rot,

Table 1. Potato seedling mortality caused by test pathogens under the field condition

Treatments	Percent mortality	
	Pre- and post-emergence	Total
T_1 (Control 1) = Only fresh seeds without any amendment	18.75 (21.88)*	40.63
T_2 (Control 2) = Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii*	37.50 (40.63)	78.13
T_3= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +only poultry refuse	12.50 (18.75)	31.25
T_4= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +200g wheat grain colonized *Trichoderma* fortified poultry compost	9.38 (18.75)	28.13
T_5= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +300g wheat grain colonized *Trichoderma* fortified poultry compost	6.25 (15.63)	21.88
T_6= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +400g wheat grain colonized *Trichoderma* fortified poultry compost	6.25 (12.50)	18.75
T_7= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +500g wheat grain colonized *Trichoderma* fortified poultry compost	3.13 (9.38)	12.50

*Post-emergence seedling mortality

which can result in significant crop losses (Rubayet & Bhuiyan, 2016; Nitu *et al*., 2016; Salam, 2017).

Assessment of disease development and disease control of potato in the field

Disease incidence and severity of stem canker and black scurf caused by *R. solani* and stem rot caused by *S. rolfsii* were significantly reduced by different doses of *Trichoderma*-fortified poultry compost in the field. The results of the incidence and severity of stem canker and black scurf and stem rot are presented in Table 2-3. The incidence of stem canker and black scurf disease ranged from 7.83-55.75%. The highest 84.35% disease reduction occurred in the treatment T_7 in *R. solani* inoculated, followed by T_6 and T_5. The lowest (53.28%) disease reduction occurred in treatment $T_{3,}$ where only poultry refuse was applied, followed by T_4. Disease incidence reduction in treatment T_7 was significantly superior to all other treatments.

The incidence of stem rot disease ranged from 8.64-51.77%. The highest 82.92% disease reduction was observed in treatment $T_{7,}$ which was statistically similar to T_6 and T_5. The lowest 45.46% disease reduction was recorded in the treatment T_3 where only poultry compost was applied followed by $T_{4.}$ Disease incidence reduction in the treatment T_7 was significantly superior to all other treatments. A similar pattern was also observed in disease severity. Poultry compost mixed with *T. harzianum* isolate efficiently controlled seedling mortality and reduced disease incidence and disease severity in tomato (Rahman, 2013 and Salam, 2017).

Table 2. Effect of different doses of *T. harzianum* fortified poultry compost on disease incidence of soil-borne diseases of potato in the field

Treatments	% Disease incidence**	
	R. solani	*S. rolfsii*
T_1 (Control 1) = Only fresh seeds without any amendment	28.88 b (26.87)	28.92 b** (44.14)*
T_2 (Control 2) = Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii*	55.75 a (0.00)	51.77 a (0.00)
T_3= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +only poultry refuse	25.26 bc (30.49)	27.59 b (46.71)
T_4= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +200g wheat grain colonized *Trichoderma* fortified poultry compost	21.41 bc (34.34)	17.15 c (66.87)
T_5= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +300g wheat grain colonized *Trichoderma* fortified poultry compost	17.73 cd (38.02)	14.32 cd (72.34)
T_6= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +400g wheat grain colonized *Trichoderma* fortified poultry compost	16.72 cd (39.03)	12.24 cd (76.36)
T_7= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +500g wheat grain colonized *Trichoderma* fortified poultry compost	7.83 d (47.92)	8.64 d (83.31)

* Percent disease incidence reduction over control 2 (T_2)
**The same letter(s) within a column indicates no significant difference (*P=0.05*) according to DMRT test

Table 3. Effect of different doses of *Trichoderma* fortified poultry compost on disease severity of soil-borne diseases of potato in the field

Treatments	Percent Disease Index	
	R. solani	*S. rolfsii*
T_1 (Control 1) = Only fresh seeds without any amendment	36.67 b (29.03)	35.00 b (32.26)*
T_2 (Control 2) = Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii*	51.67 a (0.00)	51.67 a (0.00)
T_3= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +only poultry refuse	28.33 c (45.17)	30.00 bc (41.94)
T_4= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +200g wheat grain colonized *Trichoderma* fortified poultry compost	23.33 cd (54.85)	25.00 cd** (51.62)
T_5= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +300g wheat grain colonized *Trichoderma* fortified poultry compost	18.33 de (64.52)	20.00 d (61.29)
T_6= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +400g wheat grain colonized *Trichoderma* fortified poultry compost	13.33 ef (74.20)	16.67 de (67.74)
T_7= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +500g wheat grain colonized *Trichoderma* fortified poultry compost	6.67 f (87.09)	10.00 e (80.65)

* Percent disease severity reduction over control 2 (T_2)
**Means within a column followed by the same letter(s) does not differ significantly (*P=0.05*) according to DMRT test

Effect of *Trichoderma* fortified poultry compost on growth factors of potato in the field

Growth promoting factors, including plant height, no. of stem/hill, fresh and dry shoot weight, fresh and dry root weight were recorded randomly, taken three plants from each replication of all the treatments after attaining certain maturity. All the treatments significantly increased the growth promotion components compared to the control 1 and control 2 plots. The highest plant height, number of stem/hill, fresh and dry shoot weight, and fresh and dry root weight were recorded in the treatment T_7 followed by T_6 and $T_{5,}$ which were identical to T_7. Significantly the lowest growth-promoting components were observed in the control treatment T_2 followed by T_1 (control 1) and T_3. In case of all growth promoting parameters, treatment T_7 performed better than all other treatments (Table 4). In numerous studies, *Trichoderma* strains have been shown to stimulate plant growth through the production of plant-growth-promoting (PGP) compounds (Vinale *et al*., 2009; Druzhinina *et al*., 2011; Hossain *et al*., 2017 and Rubayet and Bhuiyan, 2023). Therefore, plant growth promotion of potato plants by Trichoderma-fortified composts might be achieved through the production of phytostimulating compounds.

Table 4. Enhancing potato growth and suppressing *R. solani* and *S. rolfsii* with Trichoderma-fortified poultry compost

Treatments	Plant height (cm)	No of branch	Fresh Shoot wt (g)	Dry Shoot wt (g)	Fresh Root wt (g)	Dry Root wt (g)
T_1 (Control 1) = Only fresh seeds without any amendment	27.00	2.20	230.60	72.30	17.92	4.18
T_2 (Control 2) = Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii*	25.00	1.60	176.30	66.30	14.39	3.90
T_3= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +only poultry refuse	27.60	2.40	242.20	74.27	22.30	6.90
T_4= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +200g wheat grain colonized *Trichoderma* fortified poultry compost	29.30	2.60	260.80	81.66	24.90	6.30
T_5= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +300g wheat grain colonized *Trichoderma* fortified poultry compost	30.80	3.60	264.30	84.39	25.02	7.49
T_6= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +400g wheat grain colonized *Trichoderma* fortified poultry compost	31.60	3.80	278.50	85.60	28.57	8.27
T_7= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +500g wheat grain colonized *Trichoderma* fortified poultry compost	33.60	4.40	301.80	90.65	30.90	8.79

Effect of *Trichoderma* fortified poultry refuse on the tuber yield of potato

The yield of potato was significantly different among the treatments. The highest potato yield (30.94 tons/ha) was recorded in the treatment T_7 followed by T_6, T_5, T_4 and T_3, which were all superior to the T_1 and T_2 control plots (Table 5). The lowest yield, 12.17 and 16.39 tons/ha, was recorded in the treatment T_2 (Control 2) and T_1 (Control 1), respectively. Significantly higher yields of 154.23% and 88.78% were achieved with the T_7 treatment compared to Control 2 and Control 1, respectively. Similar results were also observed by many researchers who attended to the increasing yield of potato and other crops by applying *Trichoderma* fortified compost (Rahman, 2013, Nitu *et al.*, 2016, Rubyet and Bhuiyan, 2016; Salam, 2017).

Estimation of population dynamics of *Trichoderma harzianum* in the field soil of potato

Before the application of *Trichoderma*-fortified poultry compost in the field, *Trichoderma* spp. population was more or less similar. The population range varied from 10×10^4 to 11.67×10^4 cfu/g. But after the application of wheat grain colonized *Trichoderma* fortified poultry compost, the population density of *Trichoderma* spp. changed vividly (Table 6). During the counting period, the highest number of *Trichoderma harzianum* population was found in the treatment T_7, followed by T_6, T_5 and T_4, where 500, 400, 300 and 200 g wheat grain colonized *Trichoderma* fortified poultry compost was applied in the soil, respectively. The highest 68.33×10^4 cfu/g of *Trichoderma harzianum* was counted three

Table 5. Effect of different doses of *Trichoderma* fortified poultry refuse on the yield of potato in the field

Treatments	Yield (ton/ha)	% Yield increased over T_2
T_1 (Control 1) = Only fresh seeds without any amendment	16.39 f	34.68
T_2 (Control 2) = Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii*	12.17 g	-
T_3= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +only poultry refuse	17.27 e	41.91
T_4= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +200g wheat grain colonized *Trichoderma* fortified poultry compost	22.89 d	88.09
T_5= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +300g wheat grain colonized *Trichoderma* fortified poultry compost	27.61 c	126.87
T_6= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +400g wheat grain colonized *Trichoderma* fortified poultry compost	28.17 b	131.47
T_7= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +500g wheat grain colonized *Trichoderma* fortified poultry compost	30.94 a	154.23

Table 6. Population density of *T. harzianum* at different time intervals in the experimental field soil of potato

Treatments**	Before application (× 10^4 cfu/g)	One month after Application (× 10^4 cfu/g)	Two months after Application (× 10^4 cfu/g)	Three months after Application (× 10^4 cfu/g)	One month after harvest (× 10^4 cfu/g)
T_1	10.00 a*	11.33 f	13.33 f	13.00 f	13.33 f
T_2	10.00 a	11.00 f	13.33 f	11.33 f	11.67 f
T_3	10.00 a	16.33 e	19.00 e	23.33 e	20.33 e
T_4	11.33 a	22.67 d	34.67 d	39.00 d	35.00 d
T_5	11.67 a	27.67 c	46.00 c	49.67 c	45.00 c
T_6	11.33 a	31.67 b	53.33 b	58.67 b	54.00 b
T_7	10.67 a	39.33 a	61.00 a	68.33 a	60.00 a

*Means within a column followed by the same letter(s) does not differ significantly (*P=0.05*) according to DMRT test.** T_1 (Control 1) = Only fresh seeds without any amendment, T_2 (Control 2) = Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii*, T_3= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +only poultry refuse, T_4= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +200g wheat grain colonized *Trichoderma* fortified poultry compost, T_5= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +300g wheat grain colonized *Trichoderma* fortified poultry compost, T_6= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +400g wheat grain colonized *Trichoderma* fortified poultry compost, T_7= Fresh seeds+ Soil inoculated with *R. solani* and *S. rolfsii* +500g wheat grain colonized *Trichoderma* fortified poultry compost

months after *Trichoderma*-fortified poultry compost was applied in treatment T_7. The lowest11.00×10^4 cfu/g of *T. harzianum* was counted one month after Trichoderma fortified poultry compost was applied in the control treatment T_2. Initially, the population was fewer (before application), but gradually the population increased at one, two and three months after the Trichoderma fortified poultry compost application. This could be due to the competition and antagonistic effect in the rhizosphere. One month after potato harvesting, the population decreased; this might be because of the exhaustion of the nutrients from the rhizosphere. The present findings agree with the study of Asha *et al*. (2013), who assessed the population of *Trichoderma* spp. by dilution plating technique at 15, 30 and 45 days after sowing. The highest population was counted at 45 days, followed by 30 and 15 days. The soil moisture content is the main factor responsible for this time-to-time variation (Singh *et al.*, 2016).

Conclusion

Based on the present study, it can be concluded that utilization of *T. harzianum*-fortified poultry compost in potato cultivation led to promising results. This approach effectively controlled soil-borne potato diseases while enhancing growth-attributing components, leading to a significant increase in potato yield to 833 kg/ha. The application of 500 g of this compost per 6 m^2 plot demonstrated excellent performance. Additionally, the population density of *T. harzianum* grew dramatically throughout the potato growth period, and remained at substantial levels even after harvest, which is highly encouraging. In summary, the findings of this study indicate that *T. harzianum*-fortified poultry compost holds great potential for optimizing potato production, improving crop health, and contributing to higher yields.

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