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Comparative study of three *Trichoderma asperellum i*solates on inhibition of plant pathogenic fungi and plant growth promotion

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An investigation was conducted to assess the *in vitro* effect of *Trichoderma asperellum* isolates on inhibition of plant pathogens *Rhizoctonia solani*, *Fusarium oxysporum*, *Sclerotium rolfsii* and *Sclerotinia sclerotiorum*, and plant growth promotion with respect to wheat, cabbage, mustard and chilli. T3 (NI) inhibition percentage level (72.96%, 59.21%, 54.82% and 56.81%) gave the highest levels of inhibition followed by a colchicine treated mutant T2 (MU) (65.15%, 46.07%, 47.34% and 50.11%) inhibition. *T. asperellum* demonstrated significantly higher plant growth stimulation activity in all the crop seeds compared to control and were statistically equivalent with each other. However, the *T. asperellum* isolates did not record any difference with respect to germination percentage of cabbage and vigour index of wheat. The three *T. asperellum* isolates showed variation on radial growth at different pH levels tested, T1 (MC) and T2, (MU) isolates recorded the maximum radial growth in pH 7 and T*f* (NI) isolates recorded the highest radial growth in pH 6. At pH 7, all three *T. asperellum* isolates produced the most biomass (fresh weight and dry weight).

Keywords : Chilli, cabbage, growth promotion, inhibition, pH, *Trichoderma asperellum*

INTRODUCTION

Trichoderma comprises of a large number of filamentous fungal strains that are rhizocompetent and may be found in a wide range of habitats with varying climatic zones (Gorai *et al*. 2020; Samuels, 2006). Among mycoparasitic fungi *Trichoderma* spp. are regarded as one of the most effective biocontrol agents. *Trichoderma* can be used to prevent pathogens from causing diseases as well as to improve crop growth since they act as symbionts (Hoyos-Carvajal and Bissett, 2011; Zhang *et al*. 2015) because of their increased synthesis of growth regulators, organic acids and siderophores (Contreras-Cornejo *et al*. 2009; Hermosa *et al*. 2013). Antagonism and symbiotic connection were shown to be more successful with native *Trichoderma* strains.

As a result, many *Trichoderma* strains and local isolates have been studied in terms of growth (Adan *et al.* 2015) and in boosting seedling emergence, plant height, fresh weight, and vigour percentages in diverse vegetable plants as well as stimulation of root growth by colonization in the roots and rhizosphere (Harman *et al.* 2004). Biological control using potential microorganisms with considerable antifungal activity is emerging as an alternative strategy for disease management that is also eco-conscious and ecologically friendly. *Trichoderma* species are among the world's most extensively used safe microbial biocontrol agents (BCAs). (Kamala and Devi, 2012). The most important abiotic factors are host susceptibility, inoculum concentration, pH, moisture, and temperature. At pH levels ranging from 2 to 7, *Trichoderma* isolates exhibited the highest rates of sporulation and proliferation (Bandyopadhyay *et al*. 2003, Begoude *et al*. 2007). Now-a-days, one of the most important tactics in the world is certainly the utilisation of growth-promoting microorganisms in plants to boost agricultural productivity (Aloisio *et al.* 2019). Several studies have found *Trichoderma* species to be plant growth promoters. This trait is isolate-specific rather than species-specific, with varying degrees of plant specificity displayed by various isolates. The most common sign of growth promotion is an increase in root and shoot biomass, although

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there have also been reports of alterations in plant structure and development (Stewart and Hill, 2014). With this in mind, the present investigation was carried out to study three *Trichoderma asperellum* isolates, out of which two strains were isolated and the third, a mutant of *Trichoderma asperellum* generated using colchicine in the department of Plant Pathology, SAS, Nagaland University (Lemtor, 2022) were tested to check its inhibition of plant pathogenic fungi and to investigate the effects of the three *Trichoderma asperellum* isolates on plant growth promotion.

MATERIALS AND METHODS

Three dissimilar isolates of *Trichoderma asperellum* viz., i) *Trichoderma asperellum* (MU), is a mutant strain generated using 0.1% colchicine, was obtained from department of plant pathology laboratory, SAS, Nagaland University ii) *Trichoderma asperellum* (MC), which is the parent strain from which the mutant strain was generated it was isolated from the campus SAS, Nagaland University iii) *Trichoderma asperellum* (NI) which is a native strain, both *Tichoderma asperellum* (MC) and *Trichoderma asperellum* (NI) was obtained from stock culture available in the department of plant pathology, SAS Nagaland University which was isolated from different locations and four phytopathogens used in the experiment viz., *Fusarium oxysporum* f.sp *lycopersici*, *Rhizoctonia solani*, *Sclerotium rolfsii*, and *Sclerotinia sclerotiorum* were also obtained from the stock culture available in the department of plant pathology, SAS Nagaland University, Medziphema and were preserved on PDA slants at 4 ^{0}C.

Evaluation of three diferent isolates of *Trichoderma asperellum on inhibition of the plant pathogenic fungi*

This was done using the dual culture plate technique with five replication each and the growth inhibition was estimated with the formula as provided by Vincent (1947), which is outlined below.

Formula

$$GI\ (\%) = \frac{C-T}{C} \times 100$$

Where,

GI = Growth inhibition of the pathogen
C = Average radial growth (mm) of the pathogen in control plates
T = Average radial growth (mm) of the pathogen in treated plates.

Plant growth promotion activity of three different isolates of Trichoderma asperellum

To test the effectiveness of three different isolates of Trichoderma asperellum on crop seeds.

T. asperellum isolates were tested against four distinct crop seeds (wheat, mustard, cabbage, and chilli seeds). Seeds with no visible fractures or other deformations were selected and surface sterilised for 10 minutes with 1% sodium hypochlorite solution. After three washes with sterile distilled water, the seeds were air dried.

With the addition of 2% starch (w/v) as an adhesive, a seed coating was prepared from spore suspension. The seeds were dipped for 1-2 minutes, in a seed coating mixture containing (5×10 to the power 5 spores/ml) for each *Trichoderma* strain. Seeds for the water control were dipped in sterile distilled water, while seeds for the untreated control were dipped in a 2% starch solution. The laminar air flow chamber was used to air dry seeds. Treated seedlings were put in Petri plates lined with two layers of Whatman filterpaper that had been soaked in sterile distilled water for the *in-vitro* experiment, and they were then incubated in the dark at 25 °C (Asaduzzaman *et al*. 2013). After 10 days, data were recorded on the vigour index and germination % and were statistically analyzed. The vigour index for each treatment was calculated using the technique, described by Abdul-Baki and Anderson (1973). After 10 days, data on germination and root and shoot length were collected from all crop seeds treated with isolates of *Trichoderma*. Utilising the following formula, germination percentage and vigour index were obtained.

$$\text{Germination percentage} = \frac{\text{Total no. of seed germination}}{\text{Total no. of seeds sown}} \times 100$$

Where, Vigour index = [Mean of root length (cm) + Mean of shoot length (cm)] × percentages of seed germination.

For preparation of the spore suspension, at first mycelial discs (1.2 cm diam.) extracted from 4-5-day-old cultures of the *Trichoderma* strains were taken out and transferred to 50ml PDA in a separate 250ml conical flask for 4-5 days of incubation at 28°C. At the end of incubation period, each culture flask received 30ml of sterile, distilled water. The flasks were then agitated for 30 minutes at 50rpm in an orbital shaker. Then, sterile muslin cloth was used to filter the contents of each conical flask. The filtrate with the spores were collected, and a haemocytometer was employed under a light microscope to adjust the spore suspension's concentration to 5×10 to the power 5 (in symbol not in words) conidia/ml. (Asaduzzaman *et al*. 2013).

Optimization of pH for growth

Five distinct pH ranges (4, 5, 6, 7 and 8) were maintained to investigate the different isolates of *T. asperellum* mycelial growth variation at various pH levels. 0.1N hydrochloric acid and/or 0.1N sodium hydroxide were added to PDA medium to achieve the appropriate pH value. All conical flasks containing media were sterilized at 15lb/inch² for 20 mins in an autoclave. Each sterilised Petri plate was filled with 20ml PDA medium for each pH level, and then allowed to solidify. Five mm mycelial discs from the 24 hour-old, actively developing cultures of various isolates of *T. asperellum* were inserted in the centre of the Petri plates. Four replications were kept for each treatment. Inoculated plates were incubated at 25±1ºC till it's fully covered the plates. Mycelium growth in all three isolates was measured radially (in cm) for every 24 hours interval until the plates were completely covered. The same treatment was used to weighed the fresh weight and dry weight of the mycelium in conical flasks with PDB (50ml). *T. asperellum* fresh and dry weights were determined using a five-day-old culture. A sterile 5mm metal corkborer was used to remove mycelial discs of 5mm diameter from the colonies' borders. Using a sterile inoculating needle, one mycelial disc was put to each flask containing 50ml PDB. The infected flasks were kept at 25°C for five days. After filtering the mycelial mats using Whatman No. 42 filter paper, the isolates' mycelial fresh weight was calculated. The isolates' dry weight was obtained after drying at 60ºC for 24hrs in a hot air oven**.** The following method was used to calculate fungal growth on a fresh weight and dry weight basis:

$W = W_2 - W_1$

W= Weight of the mycelial mat

W_1= Weight of the filter paper

W_2= Total weight of the fungal mycelial mat and filter paper.

Statistical Analysis

The data of research work was statistically analysed by analysis of variance (ANOVA) given by (Panse and Sukhatme, 1954) and probability at a 5% level of significance was used to examine the importance of various sources of variation**.**

RESULTS AND DISCUSSION

Evaluation of three different isolates of Trichoderma asperellum on inhibition of the plant pathogenic fungi

The effectiveness of three different isolates of *Trichoderma asperellum* viz., the parent strain T1 (MC), a mutant isolate treated with colchicine T2 (MU), and a native isolate T3 (NI) against the plant pathogens *Sclerotium rolfsii, Sclerotinia sclerotiorum, Rhizoctonia solani,* and *Fusarium oxysporum*, was evaluated using the dual culture method. Among the three *T. asperellum* isolates, T3 (NI) recorded significantly higher inhibition of *R. solani* (72.96%), *Fusarium oxysporum* (59.21%), *Sclerotium rolfsii* (54.82%), *Sclerotinia sclerotiorum* (56.81%) followed by T3 (MI) at *R. solani* (65.15%), *Fusarium oxysporum* (46.07%), *Sclerotium rolfsii* (47.34%), *Sclerotinia sclerotiorum* (50.11%) inhibition (Table 1, Figs.1&2), a mutant obtained through colchicine treatment of *T. asperellum*. This impact might have been caused by mycoparasitism, which involves recognising the host, attacking, penetrating it and killing the pathogens. (Kubicek *et al*. 2001; Howell ,2003; Woo *et al*. 2006), or through antibiosis, which hinders the growth of pathogens by *Trichoderma* as a consequence of

the diffusion of an antibiotic such gliovirin, gliotoxins, viridin, etc., or as a result of resource rivalry between *Trichoderma* and the pathogens (Benitez *et al.* 2004). The results of the current study were comparable to those of Manjunath *et al*. (2017), who discovered that the plant diseases *S. rolfsii* Sr1, *S. rolfsii* Sr3, *A. solani*, and *Fusarium oxysporum* were all successfully combatted by *T. asperellum*. Numerous studies have also been conducted to determine how *Trichoderma* spp. reacts to the same four fungal phytopathogens. *Trichoderma* spp. destroyed the cell walls of *R. solani, S. sclerotiorum, F. oxysporum,* and *S. rolfsii's* hyphae before penetrating them (Siameto *et al*. 2000; Naeimi *et al.* 2010; Devi and Singh, 2012). The highest efficacy was demonstrated by *T. asperellum* mutants obtained with 0.1% concentration of colchicine, which inhibited *F. oxysporum* f. sp. *pisi* by 93.39%, while *T. harzianum* mutants obtained with 0.1% colchicine recorded the highest inhibition of 86.08% for the same pathogen, as opposed to 46.37% and 41.77% in control, respectively (Lemtor *et al*. 2022).

Plant growth promotion activities of the Trichoderma asperellum isolates

All the three isolates of *T. asperellum* demonstrated plant growth enhancement activity in all the crop seeds compared to controls and were statistically at par with each other. In chilli, seed treatment with T2 (MC) gave highest germination percentage of 91.99% which was statistically equal with T3 and T4 while the least effect was detected in T1 (70%) which was satistically equivalent with T0 (Table 2, Fig. 3). T, (4.93%) had the highest vigour index which was statistically equivalent to T3 and T4 lowest effect was seen in T1 (3.76%) which was statistically at par with T0 (Table 2, Fig. 4). *T. asperellum* isolates exhibited the earliest and quickest rate of germination in our investigation, which has also been observed by multiple researchers in various plants (Hanson, 2000; Mishra and Sinha, 2000; Oyarbide *et al*., 2001). Assaduzman *et al*. (2013) observed that compared to the control, *Trichoderma* strains increased the germination rate of the chilli plant. The germination percentage of chilli seeds was greatly improved by *T. harzianum* IMI 392432, followed by *T. harzianum* IMI 392433, *T. harzianum* IMI 392434, *T. virens* IMI 392430, and *T. pseudokoningii* IMI 392431, out of the five *Trichoderma* strains examined in both lab and field condition. The *T. harzianum* IMI 392432 treatment of the chilli seed yielded the highest vigour index values, both in laboratory and field conditions. Whereas the control yielded the lowest vigour index (Asaduzzaman *et al*. 2013). In mustard seed, the highest germination percentage was given by T3 (MU) with 91.98% which was statistically at par with T2 and T4, the

Table 1: Effect of antagonistic activity of three different isolates of *Trichoderma asperellum* against different plant pathogens.

	Percent inhibition of mycelial growth			
Trichoderma asperellum isolates	*Fusarium oxysporum.*	*Sclerotinia sclerotiorum*	*Sclerotium rolfsii*	*Rhizoctonia Solani*
T0 (control)	0.00 (0.03)	0.00 (0.03)	0.00 (0.03)	0.00 (0.03)
T_1 (MC)	40.18 (39.34)	43.43 (40.09)	41.94 (40.34)	54.22 (40.22)
T_2 (MU)	46.07 (42.74)	50.11 (44.36)	47.34 (43.47)	65.15 (47.29)
T_3 (NI)	59.21 (50.32)	56.81 (49.53)	54.82 (47.77)	72.96 (52.91)
SEm±	0.62	1.38	0.77	0.99
CD(p=0.05)	1.86	4.14	2.29	2.96

Note: Values in parentheses are angular transformed values

Table 2 : Effect of three different isolates of *Trichoderma asperellum* on germination % and Vigour Index of wheat, mustard, chilli and cabbage

Treatment	Germination Percentage				Vigour Index			
	Wheat	Mustard	Chilli	Cabbage	Wheat	Mustard	Chilli	Cabbage
T0 (Distilled water)	84.00 (66.69)	76.00 (60.78)	72.00 (58.24)	93.98 (80.41)	20.06 (26.55)	3.21 (10.22)	3.79 (11.17)	7.70 (16.08)
T_1 (2% starch solution)	80.00 (63.73)	72.00 (58.12)	70.00 (56.91)	95.98 (82.03)	20.57 (26.89)	2.72 (9.48)	3.76 (11.16)	7.92 (16.32)
T_2 (MC)	98.00 (85.52)	87.99 (73.96)	91.99 (76.92)	99.97 (89.01)	20.81 (27.09)	4.23 (11.82)	4.93 (12.79)	9.39 (17.79)
T_3 (MU)	98.00 (85.52)	91.98 (79.08)	89.99 (73.43)	99.97 (89.01)	21.32 (27.29)	5.11 (12.98)	4.84 (12.70)	9.70 (18.33)
T_4 (NI)	96.00 (83.89)	85.99 (72.34)	88.00 (72.00)	99.97 (89.01)	21.56 (27.61)	3.68 (11.04)	4.67 (12.46)	11.38 (19.72)
SEm±	2.83	5.25	3.94	3.09	1.30	0.58	0.43	0.47
CD (p=0.05)	8.33	15.49	11.09	NS	NS	1.71	1.27	1.38

*Values in parentheses are angular transformed values, NS- Non-Significant, T1(MC)- *T. asperellum* (Mother Culture), T2(MU)- *T. asperellum* (Mutant Isolate), T3(NI)- *T. asperellum* (Native Isolate).

lowest impact was seen in T1 (72%) which was statistically at par with T0 (Table 2, Fig. 3). Highest vigour index was seen in T3 (5.1%) which was statistically at par with T2 and T4, least effect was seen in T1 (2.72%) which was statistically equal to T0 (Table 2, Fig. 4). Sharma *et al.* (2012) investigated thirty strains of *Trichoderma* (*T. virens* and *T. harzianum*) for their ability to stimulate plant growth and increased mustard seed germination. In the towel paper test, mustard seeds treated with *Trichoderma showed* the highest seed germination with isolates PB 28 (100%) than the control. Maximum root lengths were observed in isolates PB 15 (80.3%), PB 6 & 30 (60%) and PB 2 & 4 (59.7%). Isolate PB 16 (28.7%) produced the longest shoot length.

In case of wheat seeds, the maximum germination percentage was seen in treatments T2 and T3 (98%), which was statistically at par (P=0.01) with T4 , and the lowest was seen in T0 (80%), which was statistically at par with T1 in the wheat plant (Table 2, Fig. 3). The vigour index of the wheat plant showed no statistically significant effect (Table 2, Fig. 4). According to Mahato *et al*. (2018), *Trichoderma viride* had a negative effect on the wheat plant by increasing plant height (4.6%) over control while decreasing root length (-17.4%). Hajieghrari and Mohammadi (2016) studied the effect of five indigenous isolates of *Trichoderma* on wheat plant and discovered that, the *Trichoderma harzianum* T969 had the highest seed germination rate, which was reported to be 95.8%. *Trichoderma hamatum* T614 isolation showed necrotic responses on rootlets, indicating its parasitic rather than symbiotic activity despite all isolates colonising on rootlets and having no significant impact on the seedling's development. In cabbage, treatments T4 (NI) produced the greatest vigour index (11.38%), followed by T3 (9.7%), which was statistically equivalent with T2 and the least impact was seen in T0 (7.70%) which was at par with T1 (Table 2, Fig. 4). However, the effect of several treatments on germination percentage of cabbage seeds was non-significant (Table 2).

According to Celar and Valic (2005), the initial and final counts of the germination of onion, chicory, and lettuce seeds were negatively influenced by the filtrates of *Trichoderma koningii, T. longibrachiatum, and T. viride*. It appears that the fungus secretes some toxic substances which hinder the germination.

The effect of compounds secreted by *Trichoderma* species/isolates on seed germination and seedling vigour depends not only on the *Trichoderma* species isolates and the type of metabolite(s) but also the plant species that react to the secreted metabolites are important (Celar and Valic, 2005; Vinale *et al*., 2012). *T. asperellum* isolates from the present research most likely generated particular metabolites that led to the lack of a substantial favourable impact on cabbage seeds germination.

Effect of pH on three different isolates of Trichoderma asperellum

The data presented in Table 3, Fig. 7 reveal that the highest radial growth was seen in pH 7 in T1 (MC) isolate, which is statistically equivalent to its growth in pH 6 and pH 5. The lowest growth was seen in pH 4. Likewise in T2 (MU) showed the highest radial growth at pH 7, and the least growth at pH 4. However, in T3 (NI) isolates, pH 6 had the maximum growth which was statistically equivalent with pH 7 and pH 5, while the least growth was seen in pH 4 in all the three isolates. Jayaswal *et al*. (2003) reported that *T. viride* growth and sporulation were suppressed by either reducing or elevating the pH below 4.5 or above 5.5, respectively. Growth and sporulation decreased proportionally when pH rose over 6.0. Growth and sporulation were relatively low at pH values of 8.0 and 8.5. *T. viride* did develop when the pH was 9.0. According to Ghidiyal and Pandey (2008) and Aanuoluwa *et al.* (2015), *Trichoderma* species prefer a pH range of 5 and 6. Ghazanfar *et al*. (2018) observed that pH ranges from 5.0 to 7.0 were optimal for all *Trichoderma* species.

When the effect of different pH level was tested on biomass production (fresh weight and dry weight) of three *T. asperellum* isolates, the highest fresh weight was seen in pH 7, T1 isolate (2.0g), T2 isolate (2.35g) and T3 isolate (1.84g) for all the three isolates, least fresh weight was observed in pH 4 and pH 8 which is statistically at par with each other (Table 4). Similarly, in terms of dry weight, again all the three isolates recorded the maximum dry weight at pH 7, T1 isolate (0.96g), T2 isolate (0.35g) and T3 isolate (0.51g) and the least dry weight was observed in pH 4 and pH 8 (Table 4, Fig. 9). According to Gurumurthy *et al*. (2016), the pH range where *Trichoderma* sp. grows the best was in between 6.5 and 7.5, with a range of 200.33 to 226.33 mg for the total dry weight of the mycelium. Singh *et al*. (2014) reported that the majority of isolates produced significant amounts of biomass at pH 6.5, followed by pH 7.5 and pH 5.5, and the smallest amounts at pH 4.0 and pH 4.5. The optimal pH ranges from 5.5 to 7.5, and the mycelium's total dry weight ranges between 1.41g and 1.30g.

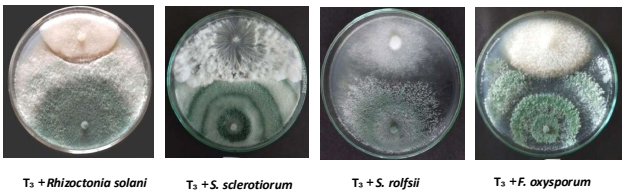


Fig. 1: Antagonistic effect of different isolates of *T. asperellum* on *Rhizoctonia solani, Sclerotinia sclerotiorum, Sclerotium rolfsii* and *Fusarium oxysporum.*

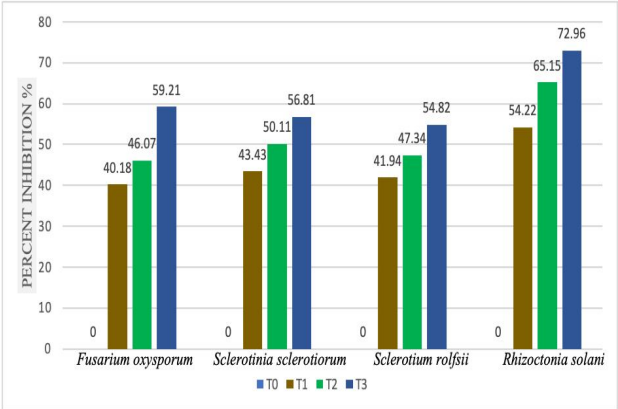


Fig. 2: Effect of antagonistic activity of different Isolates of *Trichoderma asperellum* against different plant pathogens

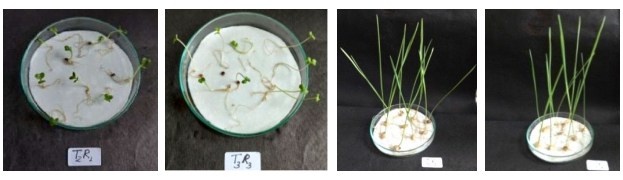


Fig. 3: Effect of three different isolates of *T. asperellum* on germination percentage of crops seed 10 days after sowing

Table 3: Effect of pH on radial growth (cm) of three different isolates of *Trichoderma asperellum*

pH	T1 (MC)			T2 (MU)			T3 (NI)		
	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3
4	1.28	3.10	4.10	1.08	1.93	3.43	1.13	2.65	3.78
5	1.35	3.25	4.40	1.28	2.35	3.60	1.43	3.33	4.28
6	1.43	3.18	4.43	1.23	2.10	3.73	1.33	2.83	4.45
7	1.68	3.43	4.50	1.35	2.20	4.13	1.50	3.05	4.43
8	1.20	3.20	4.20	1.15	1.95	3.53	1.18	2.68	4.10
SEm±	0.07	0.06	0.10	0.06	0.08	0.90	0.07	0.07	0.09
CD (p= 0.05)	0.22	0.18	0.29	0.18	0.24	0.28	0.20	0.21	0.27

*Mean of four replicates, T1(MC)-*T. asperellum* (Mother Culture), T2(MU)- *T. asperellum* (Mutant Isolate), T3(NI)- *T. asperellum* (Native Isolate)

Table 4: Effect of different levels of pH on fresh weight and dry weight of three different isolates of *Trichoderma asperellum*

pH levels	Fresh Weight			Dry Weight			% water loss.		
	T1 (MC)	T2 (MU)	T3 (NI)	T1 (MC)	T2 (MU)	T3 (NI)	T1 (MC)	T2 (MU)	T3 (NI)
4	1.32	1.42	1.13	0.47	0.51	0.11	64%	64%	90%
5	1.81	1.94	1.46	0.76	0.76	0.13	58%	60%	91%
6	1.59	2.03	1.53	0.53	0.97	0.35	66%	52%	77%
7	2.0	2.35	1.84	0.96	1.30	0.51	52%	44%	72%
8	1.42	1.43	1.10	0.35	0.64	0.08	75%	55%	92%
SEm±	0.14	0.14	0.08	0.05	0.07	0.03			
CD (p=0.05)	0.43	0.42	0.26	0.15	0.20	0.08			

*Mean of four replicates, T1(MC)- *T. asperellum* (Mother Culture), T2(MU)- *T. asperellum* (Mutant Isolate), T3(NI)- *T. asperellum* (Native Isolate)

Fig. 4: Effect of three different isolates of *T. asperellum* on vigour index of crops seed 10 days after sowing

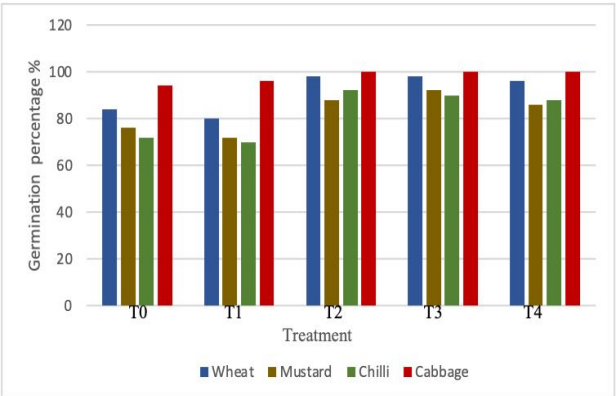


Fig. 5: Effect of three different isolates of *Trichoderma asperellum* on germination percentage of wheat, mustard, chilli and cabbage

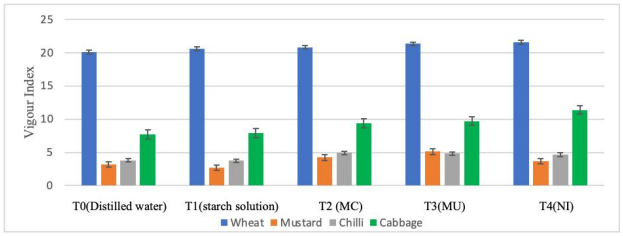


Fig. 6: Effect of three different isolates of *T. asperellum* on vigour index of wheat, mustard, chilli and cabbage

T_1 (pH7) T_2 (pH7) T_3 (pH6)

Fig. 7: Effect of different levels of pH on radial growth of three different isolates of *T. asperellum*

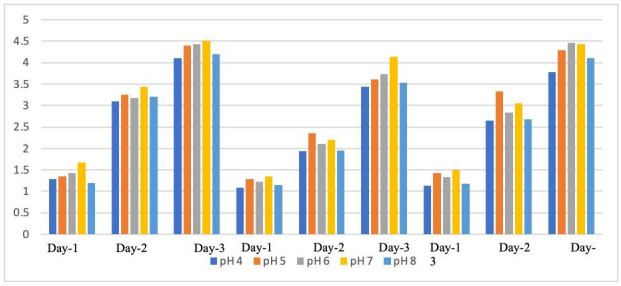
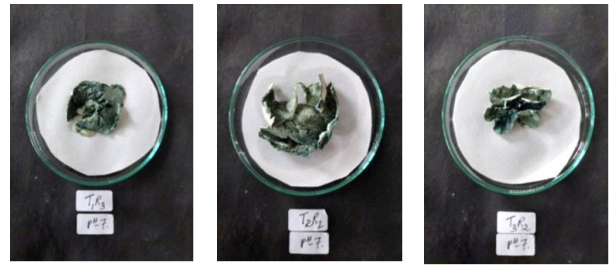
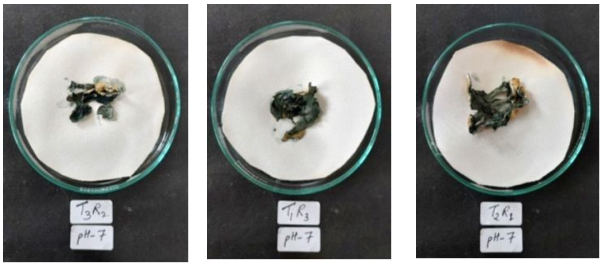


Fig. 8 : Effect of different levels of pH on radial growth (cm) of three different isolates of *Trichoderma asperellum* till it fully covered the plate



Fresh weight of the biomass



Dry weight of the biomass

Fig. 9: Effect of different levels of pH on fresh weight and dry weight of three different *T. asperellum* isolates after five days of inoculation

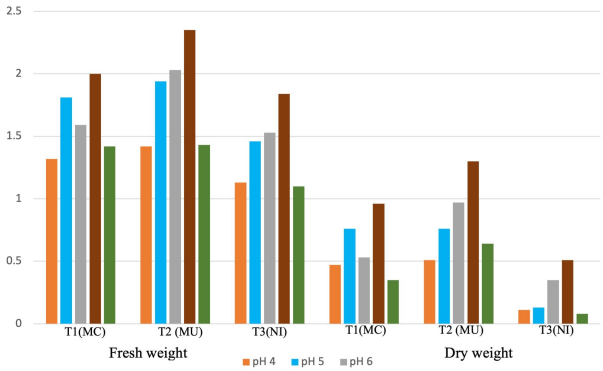


Fig. 10: Effect of different livels of pH on fresh weight and dry weight of three different isolates of *Trichoderma asperellum.*

CONCLUSION

It can be concluded that the three isolates of *T. asperellum* was effective against the growth of soil and seed borne pathogens. The mutant isolates treated with colchicine was found more significantly better than the parent strain. Plant growth promoting activity was found equally effective in all the three *T. asperellum* isolates in some of the crop seed tested. The variety of the plant, environmental factors, the metabolites produced by the *Trichoderma*, or the lack of interactions between the plant and the *Trichoderma*, may all have a significant impact on the diversity exhibited in the potential to promote plant growth. In order to successfully improve plant health, more study must be done on plant varieties, interactions between plants and *Trichoderma* species, and environmental factors. The study based on the impact of pH on radial growth and mycelial weight of *T. asperellum* suggested that pH is highly important since it affect the growth and adaptability of *Trichoderma* species. *Trichoderma* must be produced under favorable conditions before being used for commercial purposes since it is an environmentally friendly biocontrol agent that is successful in eradicating soil-borne plant pathogens.

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DECLARATION

Conflict of interest. Authors declare no conflict of interest.

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