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ORIGINAL ARTICLE

Evaluation of antagonistic potential of *Trichoderma* spp. against major pulse crop diseases

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ABSTRACT
Trichoderma spp. has been widely used as biocontrol agent due to its effective biocontrol mechanisms against various diseases of crops, attacking and suppressing the growth of plant pathogens. Hence, the present investigation aimed at assessing in-vitro antagonistic potential of Trichoderma spp. against five root rot phytopathogens viz. Fusariumsolani, Fusariumsp., Sclerotiumrolfsii, Fusarium oxysporum and Rhizoctonia bataticola.Sixty five isolates of Trichoderma spp. were isolated from rhizospheric soil of chickpea, pigeon pea, lentil and rice by serial dilution technique. All above mentioned phytopathogenic fungi were isolated from their respective diseased plant parts by tissue segment method and were purified by hyphal tip culture method. These isolates were evaluated for their biocontrol potential against phytopathogenic fungi through dual culture technique. It was found that isolate MS:Puy027 showed high percentage inhibition against F. solani, Fusarium sp., F. oxysporum and S. rolfsii (76.11%, 86.11%, 76.66% and 51.11%) and isolate MP:Kha030 showed 78.88%, 80.5%, 75% inhibition against F. solani, Fusarium sp. and F. oxysporum respectively. Isolate MP:Bhe028, MP:Kha033, MP:Gai049 and MP:Bic050 showed high inhibition when assessed against S. rolfsii whereas isolate UP:Bam002, UP:Kak011, MS:Mal019, MP:Deo022 and MS:Gop031 showed maximum inhibition against R. bataticola. These Trichoderma isolates were found best and promising which can be used as biocontrol agent for combating various prominent and dreaded diseases of pulse crop.
KEYWORDS: Biocontrol, chickpea, *Fusarium*, pigeon pea, *Rhizoctonia bataticola, Sclerotiumrolfsii, Trichoderma*

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INTRODUCTION

\Indians rely heavily on pulses a mainly chickpea, pigeon peas, mung beans and lentils for their daily protein necessities, but it is estimated that without crop protection products the pulse crop yield can fall by around 30%. Crop losses annually due to pests and diseases amount to Rs.50,000 crore ($500 billion) according to a study by the Associated Chambers of Commerce and Industry of India (croplife.org) [1, 2]. *Fusarium solani* (Mart.) Sacc.and *Fusarium oxysporum* Schlecht. are filamentous Ascomycetes soil-borne pathogen and most common species that causes vascular wilt in pulse crop [3, 4, 24]. *Rhizoctonia bataticola* (Taub.) Butler is a very important soil-inhabiting pathogenesis a serious threat to the global chickpea production [6-12], causes root rot in crop plants [13-16], when the plants are weakened due to some other stress factors [18, 19]. Incidence of dry root rot is higher in areas where average temperature exceeds 33˚C, is highly influenced by climate change [38]. Singh and Mehrotra [39] have reported that

increased root exudation by chickpea is responsible leading to increased pre-emergence damping-off of gram seedlings by *R. bataticola* at elevated temperatures.

Sclerotium rolfsii Sacc .is a necrotrophic, soil borne fungal phytopathogen that produces abundant white mycelium on infected plants, causes collar rot of chickpea [20-24]. It produces sclerotia in soil and as mycelium in crop debris and sclerotia survives several years in the absence of a host [25]. *Sclerotiumrolfsi* causal agent of collar rot of chickpea is predominant in areas with high soil moisture and warm temperature with the mortality ranging from 10-100 percent [3, 26-30, 35, 42]. *Trichoderma* spp. is known to penetrate the rind and destroy the inner sclerotial tissues [31-35], this process is facilitated by production of the enzymes β–1,3glucanase and chitinase [36]. *Trichoderma koningii* also reduced the number of sclerotia and the plant-to-plant spread of southern blight in tomato fields [37-39].

*Trichoderma*is the most frequently used fungal biological control agent, being commercialized as biopesticides, biofertilizers, and soil enhancers and have long been known as effective antagonists against plant pathogenic fungi [40, 43, 7]. *Trichoderma* provide protection against fungal diseases caused by *Phytophthora*, *Rhizoctonia*, *Sclerotium*, *Pythium*, and *Fusarium* genera [32]) and promote high yields in crops [15] indirectly by competing for nutrients and space, modifying the environmental conditions, plant defensive mechanisms and antibiosis, or directly, by mechanisms such as mycoparasitism [43].Hence forth, the selection of isolates and the assessment of their antagonistic potential against phytopathogens are the crucial steps in the development of bio-agents to control plant diseases.

Therefore, the present investigation aimed at selection and screening of *Trichoderma* strains *in-vitro* against major diseases which can effectively inhibit multiple diseases of pulse crop *in-vivo* when applied in soil as seed and soil amendment as effective bioformulations.

MATERIAL AND METHODS

Isolation of different Trichoderma sp.

The rhizospheric soil samples were collected from the different chickpea, rice, lentil and pigeonpea growing areas of Uttar Pradesh, Madhya Pradesh, Maharashtra, Andhra Pradesh and Bihar state (table 1). The whole experimental work was carried out in ICAR-National Research Centre for Integrated Pest Management (NCIPM), Pusa Campus, New Delhi in year 2014.The fungal isolations were carried out by serial dilution technique [7, 40], and plating on *Trichoderma* specific medium (TSM) [14] modified by Saha and Pan [37]. The cultures were purified by repeated sub-culturing adopting hyphal tip culture method [37]. The isolates were identified up to species level based on taxonomic keys and monograph of Rifai [36] and Domsch *et al*. [11].

Isolation of phytopathogenic fungi

Phytopathogenic fungi *Fusarium solani* Sacc.and *Fusarium* spp*.* was isolated from infected pigeon pea stems collected from Badnapur (Maharashtra). Pathogen *Sclerotiumrolfsii* Curzi and *Fusarium oxysporumf.sp.ciceris* Schlecht were isolated from infected chickpea plant collected from Badnapur (Maharashtra) and *Rhizoctonia bataticola* Kuhn from chickpea stem collected from Anantapur (A.P.) field. Diseased stems were cut aseptically into 1-cm pieces, were surface sterilized in 70% ethanol and then in 1% sodium hypochlorite solution for 1 min each and were rinsed in sterile distilled water and blotted dry in sterilized blotting paper and then plated onto potato dextrose agar plates by tissue segment method [37]. Plates were incubated at room temperature (22°C) in the dark. The cultures were purified by repeated subculture by hyphal tip culture method [37] and identified on the basis of asexual reproductive structures. Cultures were maintained on PDA plates at 4°C for further study.

Screening of Trichoderma isolates for antagonistic potential by dual culture

In-vitro antagonistic potential of sixty five isolates of *Trichoderma* spp. were evaluated against phytopathogenic fungi *Fusarium solani, Fusarium* spp., *Sclerotiumrolfsii*, *Fusarium oxysporum* and *Rhizoctonia bataticola* through dual culture technique [27].

For mycelial growth inhibition of test plant pathogen by the *Trichoderma* spp., both pathogen and antagonist were inoculated at peripheral region opposite to each other in sterilized petriplates (90 mm diameter) containing 20 ml sterilized potato dextrose agar (PDA) medium. The inoculated plates were incubated at 28±1°C for 10 days and were periodically observed for the mycelial suppression of pathogens. This set of experiment was replicated five times. The PDA medium inoculated either with pathogen and antagonist only served as control. The radial mycelial growth of test pathogens and antagonist were measured periodically and the per cent inhibition of mycelial growth of test pathogen by antagonist was calculated as per formulae adopted by Garcia [17] as:

% Inhibition = 100 [(R1-R2) / R1], where R1 is the farthest radial distance covered by the pathogen in the direction of the antagonist (control) while R2 represents the distance grown on a line between inoculation positions of the pathogen and the antagonist.

RESULTS AND DISCUSSION

The results presented in Table 2, revealed that all sixty five *Trichoderma* isolates significantly inhibited the mycelial growth of pathogen compared to control, but they differed significantly among themselves and with the test pathogen. After evaluation, it was found that isolate MS:Puy027showed high percentage inhibition against *F. solani*, *Fusarium* spp., *F. oxysporum* and *S.rolfsii* (76.11%, 86.11%, 76.66% and 51.11%) and isolate MP:Kha030 showed 78.88%, 80.5%, 75% inhibition against *F. solani*, *Fusarium* spp. and *F. oxysporum* respectively. Isolate MP:Kod 006 (73.88%), MS:Mar014 (73.33%), MP:Mau023 (75%), MP:Lal037 (75.55%) and UP:Nay063 (76.66%) showed higher inhibition against *F. solani* than other isolates. Isolate UP:Sad007 (75.62%), MS:Mar014 (81.11%), MP:Mau023(75.55%), MP:Kha030 (80.5%), MP:Kod045 (77.22%), MS:Sun (78.88%),and UP:Bal058 (81.11%) showed higher inhibition against *Fusarium* spp. than other isolates tested. Isolate UP:Bam002 (78.75%), MP:Umr004 (75.62%), MP:Bhe028 (82.77%), MS:Chi055 (77.9%) and UP:Bal057 (75.55%) showed high inhibition against *F. oxysporum* as compared to other isolates tested.

Isolate MP:Bhe 028 (66.11%), MP:Kha033 (56.11%), MP:Gai049 (54.44%) and MP:Bic050 (64.44%) showed high inhibition when assessed against *S. rolfsii.* Isolate UP:Bam002 (81.66%), UP:Kak011 (88.88%), MS:Mal019 (82.77%), MP:Deo022 (78.33%) and MS:Gop031 showed maximum inhibition percentage against *R. bataticola*. All isolates of *Trichoderma* had not shown same degree of hyper parasitic activity against all test plant pathogen. Similar results were found by other researchers that the isolate *Trichoderma* TVS-1 isolated from chickpea rhizosphere is strong and virulent antagonist for effective management of chick pea wilt caused by *F.oxysporum* [25]. Seed treatment and soil application of Biowilt-X (*T. harzianum*) decreased the wilt incidence by 60 and 53% and the severity by 63 and 58%, respectively over respective control in *F. oxysporum* f.sp. *ciceris* [26].

As described in figure 1, the isolates MS: Mar014, MP:Mau023, MP:Kha030, MS:Puy027 and UP:Bam002 were found best and promising isolates for suppression of mycelial growth of test pathogens under field conditions. These results were in agreement with [39] who tested native *Trichoderma* isolates against dry root rot causing pathogen, *R. bataticola*, among them, *Trichoderma* isolate-7 (CT7) showed maximum inhibition of growth of *R. bataticola* (83.33%) followed by *Trichoderma* isolate-4 (81.11%). Amira *et al*. [3] showed comparable results that *T. harzianum* Ths97 can be employed as potent biological weapon to stop *Fusarium* root rot disease in olive trees caused by *F. solani* Fso14.Hasna *et al*. [18] found that dual culture showed that *Trichoderma* inhibited the growth of *S. rolfsii* with percent inhibition of 78.9%, induced by *Trichoderma* after 8 days of inoculation. Nagamani *et al*. (2015) showed that from twenty *Trichoderma* isolates tested against *R.bataticola*, *T. harzianum* (KNN 4and ATPP 6) showed maximum inhibition of mycelia growth by 81.1% and 79.3% respectively. Azevedo *et al*. [4] found that isolates T1, T3 and T12 of *Trichoderma* sp. produced volatile metabolites capable of inhibiting the mycelial growth of *F. solani* and *F. oxysporum* in chickpea. Recently, Khan *et al*. [20] reported disease incidence caused by root rot caused by *R. solani* and *M. phaseolina* was controlled by *T. harzianum*. Pandey *et al*. [30] evaluated that *T. harzianum* caused 80% inhibition of mycelial growth after 72hrs of incubation; and it also caused 35.5% inhibition of sclerotialformation after 10 days of incubation.

Table 1. Detail of *Trichoderma* spp. isolated from various rhizospheric soil

***Trichoderma* isolate name**	**Rhizosp-heric soil**	**Place**			**Soil pH**	**Latitude**	**Longitude**
		Village	**District**	**State**			
UP:Bam001	Rice	Bambawad	GautamBudh Nagar	Uttar Pradesh	7.2	28.55 N	77.59 E
UP:Bam002	Rice	Bambawad	GautamBudh Nagar	Uttar Pradesh	6.9	28.55 N	77.59 E
UP:Bam003	Rice	Bambawad	GautamBudh Nagar	Uttar Pradesh	6.8	28.55 N	77.59 E
MP:Umr004	Chickpea	Umreth	Chindwara	Madhya Pradesh	7.4	22.19 N	78.76 E
MP:Dol005	Chickpea	Dolapanjra	Chwarpatha	Madhya Pradesh	7.5	22.93 N	79.04 E
MP:Kod006	Chickpea	Kodia	Chwarpatha	Madhya Pradesh	7.2	22.93 N	79.04 E
UP:Sad007	Chickpea	Sadasani	Kamasin	Uttar Pradesh	6.8	25.49 N	80.88 E
UP:Kus008	Chickpea	Kusumara	Kurara	Uttar Pradesh	6.7	25.97 N	80.07 E
UP:Gur009	Chickpea	Gurdaha	Maudaha	Uttar Pradesh	6.5	25.60 N	80.15 E
UP:Gaj010	Chickpea	Gajaura	Ganjdund-	Uttar Pradesh	6.9	25.58 N	80.12 E

			wara				
UP:Kak011	Chickpea	Kakrau	Firozabad	Uttar Pradesh	7.1	27.18 N	78.39 E
UP:Pad012	Chickpea	Pahari	Mirzapur	Uttar Pradesh	7.1	25.10 N	82.37 E
MS:Sat013	Chickpea	Sategaon	Palam	Maharashtra	5.4	21.11 N	77.24 E
MS:Mar014	Chickpea	Mardasga-on	Parbhani	Maharashtra	5.6	18.99 N	76.74 E
MS:Gop015	Chickpea	Gopa	Parbhani	Maharashtra	5.9	18.99 N	76.74 E
MS:Mar016	Chickpea	Mardasga-on	Parbhani	Maharashtra	7.1	18.99 N	76.74 E
MS:Aar017	Chickpea	Aarni	Yamatval	Maharashtra	6.5	20.07 N	77.95 E
MS:Tak018	Chickpea	Takwiki	Osmanabad	Maharashtra	6.2	18.03 N	76.22 E
MS:Mal019	Chickpea	Malumbara	Gangakhed	Maharashtra	7.2	19.50 N	76.75 E
MP:Khe020	Chickpea	Kherua	Narsingpur	Madhya Pradesh	7.1	22.93 N	79.06 E
MP:Gau021	Chickpea	Gaunee	Chwarpatha	Madhya Pradesh	6.8	22.93 N	79.04 E
MP:Deo022	Chickpea	Deora	Panna	Madhya Pradesh	6.9	24.33 N	79.97 E
MP:Mau023	Chickpea	MaujaAttas	Chwarpatha	Madhya Pradesh	6.9	22.93 N	79.04 E
MP:Sim024	Chickpea	Simariya	Chwarpatha	Madhya Pradesh	7.2	24.48 N	84.92 E
MS:Jal025	Chickpea	Kategaon	Jalna	Maharashtra	6.2	19.83 N	75.88 E
MP:Bil026	Chickpea	Bilhera	Chwarpatha	Madhya Pradesh	6.6	22.93 N	79.04 E
MS:Puy027	Chickpea	Puyani	Nanded	Maharashtra	7.3	19.20 N	77.26 E
MP:Bhe028	Chickpea	BhesaKhedi	Dewas	Madhya Pradesh	6.9	23.09 N	76.30 E
MS:Sun029	Chickpea	Sunegaon	Hingoli	Maharashtra	6.6	19.25 N	77.18 E
MP:Kha030	Chickpea	Khairi	Narsingpur	Madhya Pradesh	6.9	22.93 N	79.06 E
MS:Gop031	Chickpea	Gopa	Parbhani	Madhya Pradesh	7.2	18.99 N	76.74 E
MS:Tel032	Chickpea	Telhara	Akola	Maharashtra	5.8	21.02 N	76.84 E
MP:Kha033	Chickpea	Kharera	Sagar	Madhya Pradesh	6.8	24.19 N	78.41 E
MS:Mal034	Chickpea	Malegaon	Akola	Maharashtra	5.9	20.67 N	76.98 E
UP:Gah035	Chickpea	Gahrouli	Khurd	Uttar Pradesh	6.3	28.44 N	76.97 E
UP:Lah036	Chickpea	Lahora	Muzaffarna-gar	Uttar Pradesh	6.4	29.26 N	77.69 E
MP:Lal037	Chickpea	Lalgaon	Chhindwara	Madhya Pradesh	7.6	24.81 N	81.52 E
UP:Pac038	Chickpea	Pachoha	Kamasin	Uttar Pradesh	6.2	25.51 N	80.90 E
UP:Kar039	Chickpea	Kariyapur	Auraiya	Uttar Pradesh	.63	26.67 N	79.61 E
UP:Pat040	Chickpea	Patanpur	Hamirpur	Uttar Pradesh	6.8	25.76 N	80.04 E
MS:Chi041	Chickpea	Chinchtakli	Parbhani	Maharashtra	6.1	19.01 N	76.69 E
UP:Tir042	Chickpea	Tirwa	Kannauj	Uttar Pradesh	6.8	26.95 N	79.78 E
MS:Puy043	Chickpea	Puyani	Nanded	Maharashtra	5.5	19.20 N	77.26 E
MP:Cha044	Chickpea	Chand	Chhindwara	Madhya Pradesh	6.4	21.94 N	79.12 E
MP:Kod045	Chickpea	Kodia	Chwarpatha	Madhya Pradesh	6.6	23.05 N	79.00 E
MS:Sat046	Chickpea	Sategaon	Parbhani	Maharashtra	6.4	21.11 N	77.24 E
MS:Kol047	Chickpea	Kolewadi	Pune	Maharashtra	5.9	19.29 N	73.87 E
UP:Chi048	Chickpea	Chichauli	Auraiya	Uttar Pradesh	6.9	26.03 N	81.23 E
MP:Gai049	Chickpea	Gaigohan	Parasia	Madhya Pradesh	6.7	22.49 N	78.40 E
MP:Bic050	Chickpea	Bichiyagha-ti	Chwarpatha	Madhya Pradesh	7.1	22.93 N	79.04 E
MS:Sun051	Chickpea	Sunegaon	Hingoli	Maharashtra	6.7	18.77 N	76.94 E
MP:Pad052	Chickpea	Padora	Shivpuri	Madhya Pradesh	7.2	25.35 N	77.43 E

UP:Kha053	Chickpea	Khamrakha	Banda	Uttar Pradesh	6.8	25.48 N	80.33 E
MS:Kaj054	Chickpea	Kajala	Osmanabad	Maharashtra	7.3	18.24 N	76.13 E
MS:Chi055	Chickpea	Chinchtakli	Parbhani	Maharashtra	7.5	19.01 N	76.69 E
BI:Lentil056	Lentil	-	-	Bihar	6.8		
UP:Bal057	Chickpea	Bilhera	Agra	Uttar Pradesh	6.5	27.14 N	77.93 E
UP(Bal)058	Chickpea	Bilhera	Agra	Uttar Pradesh	6.7	27.14 N	77.93 E
UP(Bal)059	Chickpea	Bilhera	Agra	Uttar Pradesh	6.9	27.14 N	77.93 E
UP(Nay)060	Pigeon pea	Nayapura	Fatehpur	Uttar Pradesh	7.0	27.47 N	81.41 E
UP(Nay)061	Pigeon pea	Nayapura	Fatehpur	Uttar Pradesh	6.9	27.47 N	81.41 E
UP(Nay)062	Pigeon pea	Nayapura	Fatehpur	Uttar Pradesh	7.2	27.47 N	81.41 E
UP(Nay)063	Pigeon pea	Nayapura	Fatehpur	Uttar Pradesh	6.8	27.47 N	81.41 E
UP(Nay)064	Pigeon pea	Nayapura	Fatehpur	Uttar Pradesh	6.6	27.47 N	81.41 E
AP(Ram)065	Chickpea	Ramnagar	Adilabad	Andhra Pradesh	7.1	19.08 N	79.56 E

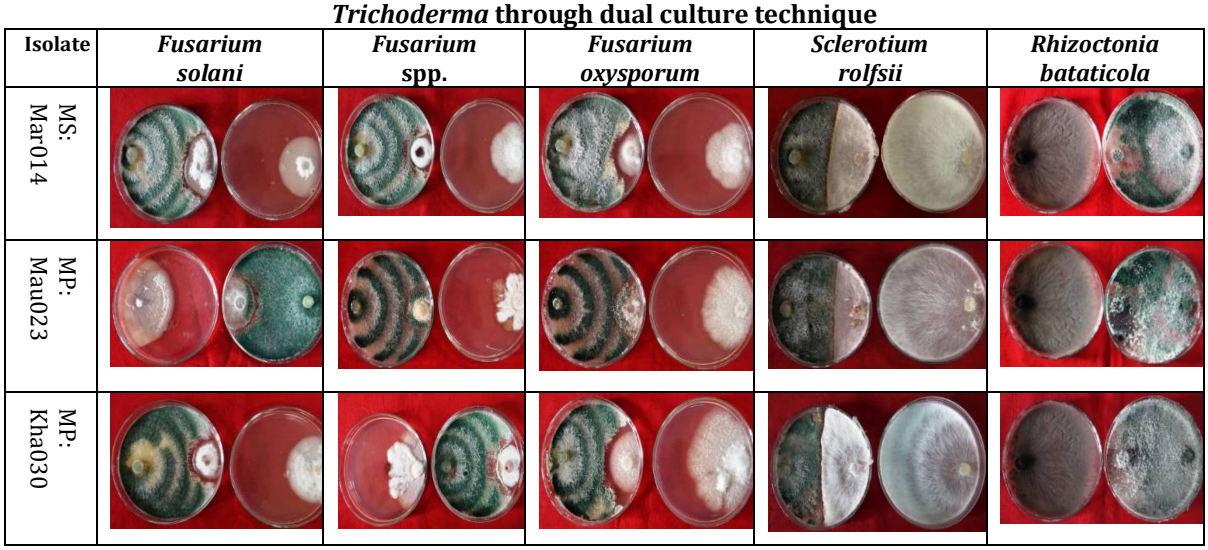
Table 2 Percent inhibition of all phytopathogens by *Trichoderma* isolates using dual culture technique

***Trichoderma* isolate code**	**% inhibition**				
	F. solani	***Fusarium* sp.**	***F. oxysporum f. sp. ciceris***	***S. rolfsii***	***R. bataticola***
UP:Bam001	*63.75	65	66.25	46.66	36.11
UP:Bam002	71.25	63.75	78.75	35.71	81.66
UP:Bam003	70	70	73.75	43.33	53.33
MP:Umr004	70.62	71.87	75.62	39.44	38.88
MP:Dol005	63.88	69.44	57.22	38.33	47.77
MP:Kod006	73.88	72.22	75.55	39.44	57.77
UP:Sad007	60.62	75.62	61	28.33	51.11
UP:Kus008	68.12	73.12	70.62	36.11	65.55
UP:Gur009	62.22	66.66	57.77	40	62.55
UP:Gaj010	62.22	72.77	49.44	45	40.55
UP:Kak011	70	65	70	50	88.88
UP:Pad012	71.77	70.55	64.44	35.55	43.11
MS:Sat013	74.8	71.66	70.6	40.22	62.88
MS:Mar014	73.33	81.11	61.11	42.77	72.22
MS:Gop015	59.44	65	56.66	34.44	43.33
MS:Mar016	73.12	70	62.5	37.7	55
MS:Aar017	67.77	63.88	63.33	30.55	62.77
MS:Tak018	66.6	62.7	60	26.11	66.66
MS:Mal019	63.88	70.55	62.77	43.33	82.77
MP:Khe020	61.11	63.88	61.66	26.11	47.77
MP:Gau021	72.99	74.6	68.9	28.66	73.88
MP:Deo022	73.33	72.22	72.22	41.11	78.33
MP:Mau023	75	75.55	71.11	38.88	27.22
MP:Sim024	65.55	62.77	63.33	35	61.11
MS:Jal025	64.44	67.7	60.5	26.11	51.66
MP:Bil026	68.33	68.33	65.55	41.66	22.22
MS:Puy027	76.11	86.11	76.66	51.11	31.66
MP:Bhe028	66.66	60	82.77	66.11	62.77
MS:Sun029	68.33	75	70.5	35.55	30.55
MP:Kha030	78.88	80.5	75	40.55	52.22
MS:Gop031	64.44	61.66	57.77	38.88	80
MS:Tor032	60	64.22	62.77	33.88	51.66
MP:Kha033	71.11	66.11	63.88	56.11	42.22
MS:Mas034	63.11	64.44	64.44	37.22	60
UP:Gah035	67.5	65.55	65.55	41.1	77.22
UP:Lah036	63.88	73.88	58.33	30	70.55

MP:Lal037	75.55	71.66	71.11	45	31.66
UP:Pac038	66.11	76.11	72.22	41.6	32.77
UP:Kar039	67.77	72.77	56.66	32.77	34.44
UP:Pat040	67.22	66.66	58.33	38.88	38.88
MS:Chi041	67.22	60.55	63.88	31.66	60
UP:Tik042	70	62.22	67.22	45	54.44
MS:Puy043	65.55	66.66	65.55	33.88	50.55
MP:Cha044	53.88	57.77	43.66	38.56	73.33
MP:Kod045	72.22	77.22	69.44	44.44	43.33
MS:Sat046	73.33	70	65.55	41.11	35.55
MS:Kol047	62.22	65.55	68.88	34.44	70
UP:Chi048	73.1	80	65	29.4	51.66
MP:Gai049	75	70	65	54.44	68.33
MP:Bic050	72.77	72.76	70	64.44	74.44
MS:Sun051	69.44	78.88	65.55	33.88	66.11
MP:Pad052	64.44	76.11	56.11	30.55	62.77
UP:Kha053	71.11	72.77	63.88	40	58.88
MS:Kaj054	69.44	71.11	60	41.66	42.77
MS:Chi055	74.88	72.6	77.9	38.22	30
BI:Lentil056	71.8	68.75	70	34.44	21.66
UP:Bal057	71.11	71.66	75.55	35.55	42.77
UP:Bal058	70	81.11	74.44	36.11	67.22
UP:Bal059	49.44	55.55	45.55	21.66	39.44
UP:Nan060	62.77	67.22	59.44	39.44	42.22
UP:Nay061	57.77	51.11	56.22	32.66	28.33
UP:Nay062	62.77	71.11	67	48.88	53.66
UP:Nay063	76.66	72.77	57.77	36.66	30.55
UP:Nay064	52.77	56.11	48.88	22.22	43.33
AP:Ram065	71.66	65.55	67.22	31.66	51.66
SEM±	0.74	0.82	0.97	1.05	2.05
CV	0.09	0.09	0.12	0.22	0.31

*percentage inhibition calculated by mean of three replication
Means in the column are statistically significant at 0.05% (p>0.0001)

Figure 1: Antagonistic ability against phytopathogenic fungiby most promising isolates of *Trichoderma* through dual culture technique



CONCLUSION

Biocontrol fungi *Trichoderma* is known to antagonize various soil borne phytopathogenic fungi *in vitro* and under greenhouse/field conditions. Nonetheless, the results of *in vitro* studies reflecting the

antagonistic potential of biocontrol agents are not equally reflected to the same degree under field condition, yet initial screening of the antagonist *in-vitro* against host fungi is of immense importance. Accordingly, strong selectivity of the isolates of *Trichoderma* in their antagonistic potential towards a particular pathogen has been observed in the present investigation.

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DECARATION OF INTERESTS
The authors have declared that no competing interest exists.

REFERENCES
1. Agrios, G.N. (2005). Plant Pathology. Elsevier Academic Press, Cambridge, MA, USA.
2. Ahsan, M.S., Kumar, M. &Upadhya, J.P. (2018).Integrated Approach for the Management of Collar Rot of Chickpea. International Journal of Current Microbiology and Applied Sciences.,7(5):3560-3569.
3. Amira, M.B., Lopez, D., Mohamed , A.T., Khouaja, A., Chaar, H., Fumanal, B., Gousset-Dupont , A., Bonhomme , L., Label, P., Goupila, P., Ribeiro, S., Pujade-Renaud, V., Julien , J.L., Auguing , D. &Venisse, J.S. (2017).Beneficial effect of *Trichoderma harzianum* strain Ths97 in biocontrolling *Fusarium solani* causal agent of root rot disease in olive trees. Biological Control.,110:70-78.
4. Azevedo, D.M.Q., Rocha, F.D.S.,Fernandes, M.D.F.G., Costa, C.A.D.M.D., Muniz, F.S., Barroso, P.D., Amaral, F. L. & Barbosa, D.M.C.D.R. (2020).Antagonistic effect of *Trichoderma* isolates and its metabolites against *Fusarium solani* and *F. oxysporum* in chickpea. Brazilian Journal ofDevelopment.,6(6):36344-36361.
5. Bastakoti, S., Belbase, S., Manandhar, S. &Arjyal, C. (2017).*Trichoderma* species as biocontrol agent against soil borne fungal pathogens. Nepal Journal of Biotechnology.,5(1):39-45.
6. Carvalho, D.D.C., Junior, M.L., Martins, I., Inglis, P.W. & Mello, S.C.M. (2014).Biological control of *Fusarium oxysporum* f. sp. *phaseoli*by *Trichodermaharzianum* and its use for common bean seed treatment. Tropical Plant Pathology.,39(5):384-391.
7. Chet, I. (1987).*Trichoderma*– application, mode of action and potential as a biocontrol agent of soil borne plant pathogenic fungi, Innovative approaches to plant disease control. John Wiley and Sons, New York, pp.137-160.
8. Coley-Smith, J.R., Ghaffar, A.&Javed, Z.U.R. (1974).The effect of dry conditions on subsequent leakage and rotting of fungal sclerotia. Soil Biology and Biochemistry.,6:307-312.
9. Dhingra, O.D. & Sinclair, J.B. (1978).Biology and pathology of *Macrophomina phaseolina*. (D Dhingra, JB Sinclair, eds.) Minas Gerais: Universidade Federal De Vicosa.
10. Dhingra, O.P. & Sinclair, J.B. (1995).Basic Plant Pathology Methods, 2nd edn. CRC press, Bocca Raton, America.
11. Domsch, K.H., Gams, W. & Anderson, T.H. (1980).Compendium of Soil Fungi. Vol.1. London, Academic Press, New York.
12. Elad, Y. & Chet, I. (1983).Improved selective media for isolation of *Trichoderma* spp. and *Fusarium* spp. Phytoparasitica.,11:55-58.
13. Elad, Y., Barak, R. & Chet, I. (1984).Parasitism of sclerotia of *Sclerotiumrolfsii* by *Trichodermaharzianum*. Soil Biology and Biochemistry.,16:381-386.
14. Elad, Y., Chet, I. &Henis, Y. (1982).Degradation of plant pathogenic fungi by *Trichodermaharzianum*. Canadian Journal of Microbiology.,28:719-725.
15. Ezziyyani, M., Pérez, C., Sid, A., Requena, M. & Candela, M. (2004). *Trichodermaharzianum* as a biofungicide for the biocontrol of Phytophthoracapsici in pepper plants (*Capsicum annuum* L.). Analytical Biochemistry.,26:35-45.
16. Farr, D.F. and Rossman, A.Y. (2014).Fungal Databases. *Systematic Mycology and Microbiology Laboratory*, ARS, USDA.
17. Garcia, E.F. (1991).Screening of fungal antagonists to control *Sclerotiumcepivorum*. Jensen, D.F.*et al*. (Eds). New approaches in biological control of soil borne diseases, IOBC/ WPRS bulletin, Copenhagen, pp.79–81.
18. Hasna, M.K., Kashem, M.A. & Ahmed, F. (2020). Use of *Trichoderma* in biological control of collar rot of soybean and chickpea. International Journal of Biochemistry Research & Review.,29(9):25-31.
19. Hwang, S.F., Gossen, B.D., Chang, K.F., Turnbull, G.D., Howard, R.J. & Blade, S.F. (2003).Etiology and impact of *Rhizoctonia* seedling blight and root rot of chickpea on the Canadian prairies. Canadian Journal of Plant Sciences.,83:959-967.
20. Khan, M.R., Haque, Z., Rasool, F., Salati, K., Khan, U., Mohiddin, F.A. &Zuhaib, M. (2019).Management of root-rot disease complex of mungbean caused by *Macrophominaphaseolina* and *Rhizoctonia solani* through soil application of *Trichoderma* spp. Crop Protection.,119:24-29.
21. Kumar, R.N. & Mukerji, K.G. (1996). Integrated Disease Management Future Perspectives. In: Mukerji, K.G., Mathur, B., Chamala, B.P. and Chitralekha, C., Eds., Advances in Botany, APH Publishing Corporation, New Delhi, pp. 335-347.

22. Kumari, A. &Ghatak, A. (2018).Variability in chickpea rot-causing soilborne necrotrophs, *Sclerotiumrolfsii* and *Macrophominaphaseolina*. Journal of AgriSearch.,5(4):247-253.
23. Latunde-Data, A.O. (1993).Biological control of southern blight disease of tomato caused by *Sclerotiumrolfsii* with simplified mycelial formulations of *Trichodermakoningii*. Plant Pathology.,42:522-529.
24. Ma, L.J., Geiser, D.M., Proctor, R.H., Rooney, A.P., O'Donnell, K., Trail, F., Gardiner, D.M., Manners, J.M. and Kazan, K. (2013).Fusarium pathogenomics. Annual Review of Microbiology.,67:399-416.
25. Mahajan, K., Sharma, J.K. &Dhage, A. (2018).Evaluation of *Trichoderma* sp. against *Fusarium* wilt of chickpea caused by *Fusarium oxysporum* f. sp. *ciceris* under *in-vitro* condition. International Journal of Current Microbiology andAppliedSciences.,7:595-599.
26. Mohiddin, F.A. & Khan, M.R. (2019).Efficacy of newly developed biopesticides for the management of wilt disease complex of chickpea (*Cicerarietinum* L.). Legume Research.,42(4):550-556.
27. Morton, D.T. &Stroube, N.H. (1955).Antagonistic and stimulatory effect of microorganism upon *Sclerotiumrolfsii*. Phytopathology.,45:419-420.
28. Nagamani, P., Biswas, M.K. &Bhagat, S. (2015).Efficacy of native *Trichoderma* spp. for the management of root rot pathogens in chickpea (*Cicerarietinum* L.). Progressive Research – An International Journal.,10(4):353-356.
29. Pande, S., Desai, S. & Sharma, M. (2010). Impact of climate change on rainfed crop diseases: current status and future research needs. Lead Papers. National Symposium on Climate Change and Rainfed Agriculture, Hyderabad: Indian Society of Dryland Agriculture, Central Research Institute for Dryland Agriculture, 010, pp.55-59.
30. Pandey, P., Sagar, G.C., Shrestha, S., Manandhar, H., Yadav, R.K. and Devkota, R. (2020).Management of collar rot disease in chickpea by *Trichoderma*species. Journal of AgriSearch.,7(3):172-176.
31. Papavizas, G.C. (1985).*Trichoderma* and *Gliocladium*: biology, ecology and potential for biocontrol. Annual Review of Phytopathology.,23:23-54.
32. Peteira, B., Martínez, B., Muñiz, Y. & Miranda, I. (2001). Molecular characterization of genetic diversity in some promising isolates de *Trichoderma* spp. por RAPD. Review Protection Veg.,16(2-3):157-158.
33. Prajapati, B.K., Patel, J.K. &Patil, R.K. (2015).Bioefficacy of *Trichoderma* spp. against *Sclerotiumrolfsii*Sacc., an incitant of collar rot of chickpea *in vitro*. The Bioscan.,10(4):1745-1748.
34. Rangaswami, G. (1958). An agar blocks techniques for isolating soil microorganism with special reference to Pythiacious fungi. Science and Culture.,24:85.
35. Redda, E.T., Ma, J., Mei, J., Li, M., Wu, B. & Jiang, X. (2018).Antagonistic potential of different isolates of *Trichoderma* against *Fusarium oxysporum*, *Rhizoctoniasolani* and *Botrytis cinerea.* European Journal of Experimental Biology.,8(2):12-19.
36. Rifai, M.A. (1969).A revision of the genus *Trichoderma*. Mycological Papers.,116: 1-56.
37. Saha, D.K. & Pan, S. (1997). Qualitative evaluation of some specific media of *Trichoderma* and *Gliocladium* spp. Journal of Mycopathological Research.,35:7-13.
38. Sharma, M., Mangala, U.N., Krishnamurthy, M., Vadez, V. &Pande, S. (2010). Drought and Dry Root of Chickpea (Abstract), 5th International Food Legumes Research Conference (IFLRC V), 2010 & 7th European Conference on Grain Legumes (AEP VII).
39. Singh, P.J. &Mehrotra, R.S. (1980). Biological control of *Rhizoctonia bataticola* on gram by coating seeds with *Bacillus* and *Streptomyces* spp. and their influence on plant growth. Plant Soil.,56:475-483.
40. Tuite, J.F. (1969). Plant pathological methods: Fungal and Bacterial. Burgess Pub.co. Minneapolis, Minn., USA, pp.293.
41. Vinale, F., Sivasithamparam, K., Ghisalberti, E.L., Marra, R., Barbetti, M.J., Li, H., Woo, S.L. &Lorito, M. (2008a). A novel role for *Trichoderma* secondary metabolites in the interactions with plants. Physiology Molecular Plant Pathology.,72:80-86.
42. Wavare, S.H., Gade, R.M. &Shitole, A.V. (2017). Effect of plant extracts, bio agents and fungicides against *Sclerotiumrolfsii* causing collar rot in chickpea. Indian Journal of Pharmaceutical Sciences.,79(4):513-520.
43. Zhang, F., Yang, X., Ran, W. &Shen, Q. (2014). *Fusarium oxysporum* induces the production of proteins and volatile organic compounds by *Trichoderma harzianum* T-E5. FEMS Microbiology Letters.,359:116-123.