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EFFICACY OF *TRICHODERMA* SPP. AND *PAECILOMYCES LILACINUS* AGAINST *MELOIDOGYNE-FUSARIUM* COMPLEX INFECTING CUMIN (*CUMINUM CYMINUM* L.)

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Efficacy of biocontrol agent, *Trichoderma* spp. against *Meloidogyne- Fusarium* complex infecting cumin was tested by applying at two different inoculum levels. The nematophagous fungi, *Paecilomyces lilacinus* was given at a particular dose to control the disease. All the treatments generally showed significantly higher plant growth parameters *viz.* root-shoot height and weight over control. Maximum increase in plant growth characters, decrease in final nematode population and wilting was observed in case of plants treated with *T. virens* (T14) at 20gm inoculum level combined with *P. lilacinus.*

Keywords : *Cuminum cyminum; Fusarium oxysporum; Meloidogyne incognita; Paecilomyces lilacinus; Trichoderma* spp.

Introduction

Cumin (*Cuminum cyminum* L.), an important spice crop in the world is affected by several diseases of fungal, bacterial and viral origin. Among fungal diseases, wilt of cumin induced by *Fusarium oxysporum f.* sp. *cumini*[1,2] is an important disease of Rajasthan and Gujarat state causing annual losses ranging from 59-100% in infested fields. Root-knot disease caused by *Meloidogyne incognita* is also a severe disease causing significant reductions in yield of cumin i.e.43% [3].

A preliminary survey of cumin growing areas of Rajasthan, revealed that most of the varieties were found susceptible to disease complex caused by both the pathogens *Meloidogyne incognita* and *Fusarium oxysporum* f. sp. *cumini.* Both of them are frequently associated in nature infecting cumin resulting in considerably greater damage to the crop than the amount of damage caused by either of the pathogen alone.

In general resistant varieties, cultural practices and chemical fungicides are advocated for the management of the disease but chemicals provide short-term measures as they are reported to induce new strains of pathogen and also have environmental hazards. Therefore, use of biotic antagonists is indispensable to evolve strategy either to eradicate or to keep the disease below economic injury level as long-term measure. Reduction or elimination of soil borne inoculum is the only effective solution to overcome the problem and this may be achieved easily through fungal antagonists.

Keeping this in view, the present study was undertaken on efficacy of different levels of *Trichoderma* spp. and use of *Paecilomyces lilacinus* against disease-complex caused by *Meloidogyne incognita* and *Fusarium oxysporum* f. sp. *cumini.*

Material and Methods

Fungal culture and inoculation: The fungus, *Fusarium oxysporum* f. sp. *cumini,* isolated from cumin roots, was grown on PDA medium for 15 days at 28 ± 2°C in BOD incubator. Pure culture of fungus prepared on PDA, was further multiplied on sorghum grains. Number of spores per gram was counted with the help of haemocytometer. Inoculum level of *Fusarium oxysporum* used in this experiment was 20 gm substrate + fungi per pot.

Nematode culture and inoculation: Root-knot nematode, *M. incognita* was isolated from the same cumin field. Pure culture was multiplied on brinjal plants. Just before the inoculation, the feeder roots of the seedlings (10 days old), were exposed by carefully removing, the adhering top layer of the soil. The required quantity of nematode suspension having 1000 freshly hatched juveniles was poured uniformly all over the exposed roots & covered immediately with the top soil. This was followed by light watering of the plants.

Earthen pots were surface sterilized and filled each with autoclaved soil. Before planting in pots, the seeds were surface sterilized or disinfected. Three week old

seedlings having almost similar growth were treated with different doses of different biocontrol fungus which were isolated from the local field and later on cultured on PDA and mass cultured on different substrates. In this experiment different fungus multiplied on tea waste and sorghum straw were used. Each plant was inoculated with 1000 active juveniles of *M. incognita* and particular doses of *Fusarium oxysporum* f. sp. *cumini*. A particular dose of nematophagus fungi, *Paecilomyces lilacinus,* multiplied on wheat bran was also given.

Following set of experiment were used for the purpose -

Decaffeinated Tea waste -

1. Decaffeinated Tea waste (TW) +biocontrol fungi (10g)+Nematode (N)+Sorghum grains (SG) +*Fusarium*(F) (20g)+wheat bran (WB)+ *Paecilomyces lilacinus* (20g)
2. Decaffeinated Tea waste (TW)+biocontrol fungi (20g)+Nematode(N)+Sorghum grains(SG)+*Fusarium*(F) (20g)+wheat bran (WB) + *Paecilomyces lilacinus* (PL) (20g)
3. TW (10g) alone
4. TW (20g) alone
5. N +(SG)+F (20g)
6. N alone
7. Control

Sorghum straw -

1. Sorghum straw (SS)+biocontrol fungi (10g) + Nematode (N) + Sorghum grains (SG) + *Fusarium* (F)(20g) + wheat bran(WB) + *Paecilomyces lilacinus* (PL) (20g)
2. SS+biocontrol fungi (20g)+Nematode(N)+Sorghum grains(SG)+*Fusarium* (F) (20g) +wheat bran (WB) + *Paecilomyces lilacinus* (PL)(20)
3. SS (10g) alone
4. SS (20g) alone
5. N+(SG) + F(20g)
6. N alone
7. Control

Each treatment was replicated five times of each stage. The experiment was conducted in the month of December. Proper care was taken through out the season.

Observations on plant growth (length, fresh weight and dry weight of shoot and root, number of galls/ root system, reproduction factor) were recorded after 90 days of inoculation. To estimate nematode population in roots, one gm of root in water was treated in a waring blender for 30 seconds. Nematodes from the pot soil were also counted. Data were analysed statistically.

Results and Discussion

Generally, there was an improvement of plant vigor in all treatments where biocontrol agent was applied. Plant inoculated with nematode or nematode and *Fusarium* without any additional treatment showed root-knot disease symptoms such as stunted growth, reduction in number and quality of seeds, yellowing of leaves and wilting of plants with their early maturation. With an increase in the biocontrol fungus inoculum level, there was a progressive increase in the plant growth parameters. Significant increase in shoot-root length, fresh and dry weight was recorded at the inoculum level of 20gm biocontrol fungus/ pot .At this inoculum level, expression of wilting symptoms was also reduced. Reduction in number of galls/ plant and reproduction factor was also observed. Thus, the rate of nematode multiplication was inversely proportional to the inoculum level. The maximum shoot height, weight (fresh and dry) and root length and weight (fresh and dry) was recorded in plants treated with *Trichoderma virens* (T14) 20gm combined with *P. lilacinus* and minimum in N+F treatment. The data on number of galls and nematode population in soil also showed significant reduction in the treatments where biocontrol agents were applied.

It was observed that *P. lilacinus* propagules colonised on the eggmasses. Eggs inside the egg masses were also parasitize by *Paecilomyces* fungus. Egg content was reduced and some eggs were found deformed. It was also observed that colonization by *P. lilacinus* was more or less restricted to the upper region of roots with high percentage and very less percentage colonization was observed in lower side of roots. Results indicate that nematophagus fungus *P. lilacinus* has biocontrol potential against root-knot infection on cumin. *P. lilacinus* has been reported to produce peptidal antibiotics *viz.* letacinin, leucinostanin and paecilotoxin[4].

Trichoderma spp. is among the most promising biocontrol agents[5]. *Trichoderma* is reported to be one of the most widely distributed soil fungi[6]. Biocontrol potential of *Trichoderma* has been studied extensively[7-9]. *Trichoderma* in particular, isolates of *T. harzianum, T. viride, T.hamatum* have been used with success against soil-borne diseases, seed-borne diseases, diseases in phyllosphere and against storage rots[10-12]. This wide range of application is due to the various antagonistic mechanisms found in different *Trichoderma* isolates enabling them to function as potent biocontrol agents on many different crops, against a wide range of pathogens and in several ecological situations. Maximum reduction in nematode and fungi was due to more aggressive and microbial antagonstic effect of *T. viride*[13]. *T. virens* and its mutants m-3 and m-7 have been found to be most effective in

Table 1. Influence of different inoculum levels of biocontrol fungi multiplied on tea waste in the management of *Meloidogyne - Fusarium* complex infecting cumin (*Cuminum cyminum* L.).

S.No.	Doses	Treatments	Effect on plant growth parameters					
			Length (cm)		Fresh wt. (gm)		Dry wt (gm)	
			Shoot	Root	Shoot	Root	Shoot	Root
1.	10g	N+F+P.L+T.h (T_1)	20.52	14.34	1.99	1.39	0.20	0.14
	20g	N+F+P.L+T.h (T_1)	21.63	15.26	2.39	1.53	0.24	0.16
2.	10g	N+F+P.L+T.h (T_2)	17.99	11.16	0.84	0.68	0.09	0.07
	20g	N+F+P.L+T.h (T_2)	18.44	11.77	1.00	0.77	0.10	0.08
3.	10g	N+F+P.L+T.h (T_3)	14.35	9.12	0.63	0.32	0.07	0.03
	20g	N+F+P.L+T.h (T_3)	14.91	9.45	0.66	0.35	0.08	0.04
4.	10g	N+F+P.L+T.h (T_4)	22.22	15.95	2.55	1.57	0.26	0.16
	20g	N+F+P.L+T.h (T_4)	24.17	17.11	2.94	1.66	0.29	0.17
5.	10g	N+F+P.L+T.h (T_5)	18.62	11.89	1.12	0.80	0.12	0.09
	20g	N+F+P.L+T.h (T_5)	19.03	12.73	1.34	0.97	0.14	0.10
6.	10g	N+F+P.L+T.h (T_6)	18.84	12.06	1.20	0.83	0.13	0.09
	20g	N+F+P.L+T.h (T_6)	20.05	13.91	1.84	1.31	0.18	0.13
7.	10g	N+F+P.L+T.h (T_7)	21.15	14.95	2.31	1.52	0.23	0.15
	20g	N+F+P.L+T.h (T_7)	21.97	15.87	2.49	1.56	0.25	0.16
8.	10g	N+F+P.L+T.h (T_8)	18.26	11.47	0.90	0.75	0.09	0.08
	20g	N+F+P.L+T.h (T_8)	19.30	13.12	1.44	1.16	0.15	0.12
9.	10g	N+F+P.L+T.h (T_9)	19.81	13.73	1.65	1.28	0.17	0.13
	20g	N+F+P.L+T.V (T_9)	20.72	14.48	2.11	1.42	0.20	0.15
10.	10g	N+F+P.L+T.V (T_{10})	14.62	9.24	0.65	0.39	0.06	0.04
	20g	N+F+P.L+T.V (T_{10})	15.51	9.88	0.68	0.46	0.07	0.05
11.	10g	N+F+P.L+T.V (T_{11})	16.66	10.34	0.72	0.52	0.07	0.05
	20g	N+F+P.L+T.V (T_{11})	17.83	11.11	0.83	0.65	0.08	0.07
12.	10g	N+F+P.L+T.V (T_{12})	18.54	11.86	1.07	0.78	0.11	0.08
	20g	N+F+P.L+T.V (T_{12})	18.79	12.01	1.16	0.82	0.13	0.09
13.	10g	N+F+P.L+T.V (T_{13})	16.39	10.14	0.71	0.50	0.07	0.05
	20g	N+F+P.L+T.V (T_{13})	17.64	10.97	0.79	0.61	0.08	0.06
14.	10g	N+F+P.L+TV (T_{14})	23.58	16.80	2.87	1.63	0.29	0.16
	20g	N+F+P.L+T.V (T_{14})	24.81	17.62	3.09	1.75	0.31	0.18
15.	10g	N+F+P.L+T.V (T_{15})	19.28	12.97	1.41	1.09	0.15	0.11
	20g	N+F+P.L+T.V (T_{15})	20.63	14.38	2.02	1.40	0.20	0.14
16.	10g	N+F+P.L+T.ha (T_{16})	22.85	16.35	2.71	1.61	0.27	0.16
	20g	N+F+P.L+T.ha (T_{16})	24.17	17.11	2.94	1.66	0.30	0.17
17.		N+F	10.42	7.22	0.51	0.24	0.05	0.02
18.		Control	27.28	19.06	4.59	2.40	0.46	0.25
19.		'N' alone	10.46	7.25	0.53	0.27	0.06	0.03
20.	10g	TW alone	27.53	19.6	4.60	2.61	0.46	0.26
	20g	TW alone	28.04	19.9	4.67	2.67	0.46	0.26
		CD at 5%	1.106	0.91	0.39	0.26	0.083	0.05

T_1 & T_9 = From Jaipur, T_2 & T_{13} = From Chittorgarh, T_3 & T_{14} = from Hardwar,
T_4, T_5, T_6 & T_{11} = From Aligarh, T_7, T_{12}, T_{15} = From Ag. Co., T_8 = From J.S., T_{10} & T_{16} = From Udaipur
T.h. = *Trichoderma harzianum* T.ha = *Trichoderma hamatum* N = Nematode (*Meloidogyne incognita)*
T.v. = *Trichoderma viride* P.l. = *Paecilomyces lilacinus* T.W. = Tea waste
T.vi. = *Trichoderma virens* F = *Fusarium oxysporum*

Table 2. Influence of different inoculum levels of biocontrol fungi multiplied on *Sorghum* straw in the management of *Meloidogyne-Fusarium* complex infecting cumin *(Cuminum cyminum* L.).

S.No.	Doses	Treatments	Effect on plant growth parameters					
			Length (cm)		Fresh wt. (gm)		Dry wt (gm)	
			Shoot	Root	Shoot	Root	Shoot	Root
1.	10g	N+F+P.L.+T.h (T_1)	20.73	14.52	2.18	1.47	0.21	0.15
	20g	N+F+P.L.+T.h (T_1)	21.89	15.85	2.47	1.55	0.24	0.16
2.	10g	N+F+P.L.+T.h (T_2)	18.13	11.39	0.88	0.74	0.09	0.08
	20g	N+F+P.L.+T.h (T_2)	18.92	12.35	1.25	0.85	0.13	0.09
3.	10g	N+F+P.L.+T.h (T_3)	14.61	9.13	0.64	0.42	0.07	0.04
	20g	N+F+P.L.+T.h (T_3)	15.02	9.63	0.67	0.39	0.08	0.05
4.	10g	N+F+P.L.+T.h (T_4)	22.71	16.23	2.67	1.60	0.27	0.16
	20g	N+F+P.L.+T.h (T_4)	24.64	17.48	3.01	1.73	0.30	0.17
5.	10g	N+F+P.L.+T.h (T_5)	18.85	12.11	1.21	0.84	0.12	0.09
	20g	N+F+P.L.+T.h (T_5)	19.36	13.15	1.46	1.19	0.15	0.12
6.	10g	N+F+P.L.+T.h (T_6)	19.01	12.71	1.32	0.95	0.14	0.10
	20g	N+F+P.L.+T.h (T_6)	20.42	14.16	1.92	1.36	0.20	0.14
7.	10g	N+F+P.L.+T.h (T_7)	21.59	15.18	2.37	1.53	0.24	0.15
	20g	N+F+P.L.+T.h (T_7)	22.34	16.09	2.58	1.58	0.26	0.16
8.	10g	N+F+P.L.+T.h (T_8)	18.96	12.65	1.27	0.89	0.13	0.09
	20g	N+F+P.L.+T.h (T_8)	19.50	13.36	1.49	1.20	0.15	0.12
9.	10g	N+F+P.L.+T.V (T_9)	20.01	13.86	1.79	1.30	0.18	0.14
	20g	N+F+P.L.+T.V (T_9)	21.00	14.89	2.28	1.59	0.23	0.16
10.	10g	N+F+P.L.+T.V (T_{10})	14.92	9.48	0.66	0.35	0.07	0.04
	20g	N+F+P.L.+T.V (T_{10})	15.73	9.96	0.68	0.47	0.08	0.05
11.	10g	N+F+P.L.+T.V (T_{11})	17.18	10.71	0.75	0.58	0.08	0.06
	20g	N+F+P.L.+T.V (T_{11})	18.05	11.20	0.86	0.72	0.09	0.08
12.	10g	N+F+P.L.+T.V (T_{12})	18.89	12.20	1.23	0.85	0.12	0.09
	20g	N+F+P.L.+T.V (T_{12})	19.12	12.75	1.36	0.99	0.14	0.10
13.	10g	N+F+P.L.+T.V (T_{13})	16.84	10.74	0.74	0.55	0.08	0.06
	20g	N+F+P.L.+T.V (T_{13})	17.78	11.09	0.82	0.63	0.09	0.07
14.	10g	N+F+P.L.+T. vi (T_{14})	24.63	17.28	2.99	1.72	0.30	0.18
	20g	N+F+P.L.+ T. vi (T_{14})	24.98	17.63	3.10	1.76	0.31	0.19
15.	10g	N+F+P.L.+ T. vi (T_{15})	19.92	13.82	1.68	1.29	0.17	0.13
	20g	N+F+P.L.+ T. vi (T_{15})	20.76	14.62	2.20	1.49	0.23	0.15
16.	10g	N+F+P.L.+ T.ha (T_{16})	23.04	16.66	2.75	1.62	0.27	0.16
	20g	N+F+P.L.+ T.ha (T_{16})	24.64	17.48	3.01	1.73	0.30	0.18
17.		N+F	10.42	7.22	0.51	0.24	0.05	0.02
18.		Control	27.28	19.06	4.59	2.40	0.46	0.25
19.		'N' alone	10.46	7.25	0.53	0.27	0.06	0.03
20.	10g	SS alone	27.26	19.07	4.58	2.40	0.46	0.25
	20g	SS alone	27.30	19.10	4.60	2.42	0.46	0.25
		CD at 5%	0.85	0.73	0.37	1.92	0.06	0.12

T_1 & T_9 = From Jaipur, T_2 & T_{13} = From Chittorgarh, T_3 & T_{14} = From Hardwar, T_4 T_5 & T_6 & T_{11} = From Aligarh, T_7, T_{12}, T_{15} = From Ag.Co. T_8 = from J.S., T_{10} & T_{16} = from Udaipur.

T.h. = *Trichoderma harzianum* Tha = *Trichoderma hamatum* N = Nematode

T.V. = *Trichoderma viride* Pl. = *Paecilomyces lilacinus* *(Meloidogyne incognita)*

T.vi. = *Trichoderma virens* F = *Fusarium oxysporum* S.S. = *Sorghum* straw

Table 3. Effect of inoculum levels of different biocontrol fungi maintained on tea waste in nematode multiplication

S. No.	Doses	Treatments	Population of root-knot nematode			% reduction over N+F	No. of galls/ root system	% reduction over 'N'+ "F'	No. of egg masses/ root system	% reduction over 'N'+ 'F'
			No. of larvae/ 250g soil	No. of females/ root system	Total					
1.	10g	N+F+P.L.+T.h (T_1)	2001	194	2195	47.39	5.66	48.12	12.63	36.17
	20g	N+F+P.L.+T.h (T_1)	1684	171	1855	55.54	4.98	54.35	11.63	41.23
2.	10g	N+F+P.L.+T.h (T_2)	3025	280	3305	20.80	7.85	28.04	15.11	23.64
	20g	N+F+P.L.+T.h (T_2)	2962	248	3210	23.07	7.67	29.69	14.85	24.96
3.	10g	N+F+P.L.+T.h (T_3)	3552	362	3914	6.20	8.73	19.98	16.74	15.41
	20g	N+F+P.L.+T.h (T_3)	3486	337	3823	8.38	8.58	21.35	16.43	16.97
4.	10g	N+F+P.L.+T.h (T_4)	1525	163	1688	59.54	4.50	58.75	11.11	43.86
	20g	N+F+P.L.+T.h (T_4)	1259	143	1402	66.40	3.72	65.90	10.22	48.35
5.	10g	N+F+P.L.+T.h (T_5)	2879	241	3120	25.23	7.52	31.07	14.73	25.56
	20g	N+F+P.L.+T.h (T_5)	2546	220	2766	33.71	6.85	37.21	14.21	28.19
6.	10g	N+F+P.L.+T.h (T_6)	2831	236	3067	26.50	7.43	31.89	14.66	25.92
	20g	N+F+P.L.+T.h (T_6)	2086	198	2347	43.75	5.87	46.19	12.91	34.76
7.	10g	N+F+P.L.+T.h (T_7)	1766	177	1943	53.43	5.16	52.70	11.96	39.56
	20g	N+F+P.L.+T.h (T_7)	1591	166	1757	57.89	4.75	56.46	11.20	43.40
8.	10g	N+F+P.L.+T.h (T_8)	2994	254	3248	22.16	7.71	29.33	14.91	24.65
	20g	N+F+P.L.+T.h (T_8)	2383	214	2597	37.76	6.53	40.14	13.96	29.45
9.	10g	N+F+P.L.+T.V (T_9)	2209	209	2418	42.05	6.19	43.26	13.51	31.73
	20g	N+F+P.L.+T.V (T_9)	1968	188	2156	48.33	5.41	50.41	12.39	37.39
10.	10g	N+F+P.L.+T.V (T_{10})	3529	341	3870	7.26	8.64	20.80	16.52	16.52
	20g	N+F+P.L.+T.V (T_{10})	3295	320	3615	13.37	8.43	22.73	16.01	19.10
11.	10g	N+F+P.L.+T.V (T_{11})	3284	304	3588	14.01	8.20	24.83	15.75	20.41
	20g	N+F+P.L.+T.V (T_{11})	3138	284	3422	17.99	7.91	27.49	15.20	23.19
12.	10g	N+F+P.L.+T.V (T_{12})	2891	243	3134	24.89	7.60	30.33	14.79	25.26
	20g	N+F+P.L.+T.V (T_{12})	2852	239	3091	25.92	7.49	31.34	14.68	25.82
13.	10g	N+F+P.L.+T.V (T_{13})	3328	315	3643	12.70	8.26	24.28	15.82	20.06
	20g	N+F+P.L.+T.V (T_{13})	3188	293	3481	16.58	8.04	26.30	15.46	21.87
14.	10g	N+F+P.L.+T.vi (T_{14})	1271	146	1417	66.04	3.85	64.71	10.34	47.75
	20g	N+F+P.L.+ T.vi (T_{14})	1036	132	1168	72.01	3.26	70.11	8.70	56.03
15.	10g	N+F+P.L.+ T.vi (T_{15})	2429	217	2646	36.59	6.60	39.50	14.06	28.95
	20g	N+F+P.L.+ T.vi (T_{15})	1990	192	2182	47.71	5.52	49.40	12.48	36.93
16.	10g	N+F+P.L.+ T.ha (T_{16})	1366	152	1518	63.62	4.11	62.32	10.65	46.18
	20g	N+F+P.L.+ T.ha (T_{16})	1259	143	1402	66.40	3.72	65.90	10.22	48.35
17.	10g	TW alone	3225	300	3525	15.52	8.13	25.84	15.58	21.27
	20g	Tea waste alone	3082	282	3364	19.38	7.93	27.31	15.13	23.54
19.		N + F	3684	489	4173	0.00	10.91	0.00	19.79	0.00
20.		Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CD at 5%					165.26		0.46		0.48	

T_1 & T_9 = From Jaipur, T_2 & T_{13} = From Chittorgarh, T_3 & T_{14} = From Hardwar,
T_4 T_5 & T_6 & T_{11} = From Aligarh, T_7, T_{12}, T_{15} = From Ag.Co. T_8 = From J.S., T_{10} & T_{16} = From Udaipur.

T.h. = *Trichoderma harzianum* Tha = *Trichoderma hamatum* N = Nematode
T.V. = *Trichoderma viride* Pl. = *Paecilomyces lilacinus* *(Meloidogyne incognita)*
T.vi = *Trichoderma virens* F = *Fusarium oxysporum* S.S. = *Sorghum* straw

Table 4. Effect of inoculum levels of different biocontrol fungi maintained on sorghum straw in nematode multiplication.

S. No.	Doses	Treatments	Population of root-knot nematode			% reduction over N+F	No. of galls/ root system	% reduction over 'N'+ "F'	No. of egg masses/ root system	% reduction over 'N'+ 'F'
			No. of larvae/ 250g soil	No. of females/ root system	Total					
1.	10g	N+F+P.L.+T.h (T_1)	1912	185	2097	50.02	5.35	50.73	12.12	39.43
	20g	N+F+P.L.+T.h (T_1)	1635	169	1804	57.00	4.89	54.97	11.34	43.32
2.	10g	N+F+P.L.+T.h (T_2)	3006	269	3275	21.94	7.77	28.45	14.98	25.13
	20g	N+F+P.L.+T.h (T_2)	2666	225	2891	31.10	7.22	33.51	14.48	27.63
3.	10g	N+F+P.L.+T.h (T_3)	3548	345	3893	7.22	8.69	19.98	16.65	16.79
	20g	N+F+P.L.+T.h (T_3)	3424	326	3750	10.62	8.47	22.00	16.22	18.94
4.	10g	N+F+P.L.+T.h (T_4)	1418	154	1572	62.53	4.23	61.04	10.74	46.32
	20g	N+F+P.L.+T.h (T_4)	1108	139	1247	70.28	3.42	68.50	9.18	54.12
5.	10g	N+F+P.L.+T.h (T_5)	2784	231	3015	28.14	7.40	31.86	14.60	27.03
	20g	N+F+P.L.+T.h (T_5)	2314	212	2526	39.79	6.39	41.16	13.82	30.93
6.	10g	N+F+P.L.+T.h (T_6)	2591	221	2812	32.98	6.98	35.72	14.27	28.68
	20g	N+F+P.L.+T.h (T_6)	2012	196	2208	47.37	5.78	46.77	12.75	36.28
7.	10g	N+F+P.L.+T.h (T_7)	1729	174	1903	54.64	5.07	53.31	11.89	40.57
	20g	N+F+P.L.+T.h (T_7)	1479	157	1636	61.01	4.41	59.39	10.93	45.37
8.	10g	N+F+P.L.+T.h (T_8)	2624	224	2848	32.12	7.09	34.71	14.32	28.43
	20g	N+F+P.L.+T.h (T_8)	2292	211	2503	40.34	6.24	42.54	13.64	31.83
9.	10g	N+F+P.L.+T.V (T_9)	2134	202	2336	44.32	5.96	45.11	13.12	34.43
	20g	N+F+P.L.+T.V (T_9)	1845	180	2025	51.73	5.20	52.11	12.00	40.02
10.	10g	N+F+P.L.+T.V (T_{10})	3457	332	3789	9.69	8.52	21.54	16.30	18.54
	20g	N+F+P.L.+T.V (T_{10})	3357	319	3676	12.39	8.33	23.29	15.99	20.08
11.	10g	N+F+P.L.+T.V (T_{11})	3222	298	3520	16.11	8.11	25.32	15.54	22.33
	20g	N+F+P.L.+T.V (T_{11})	3017	276	3293	21.52	7.80	28.17	15.00	25.03
12.	10g	N+F+P.L.+T.V (T_{12})	2755	228	2983	28.90	7.36	32.22	14.53	27.38
	20g	N+F+P.L.+T.V (T_{12})	2477	219	2696	35.74	6.72	38.12	14.19	29.08
13.	10g	N+F+P.L.+T.V (T_{13})	3269	301	3570	14.91	8.15	24.95	15.62	21.93
	20g	N+F+P.L.+T.V (T_{13})	3146	288	3434	18.16	7.98	26.51	15.32	23.43
14.	10g	N+F+P.L.+T.vi. (T_{14})	1147	141	1288	69.30	3.50	67.77	9.95	50.27
	20g	N+F+P.L.+ T.vi. (T_{14})	1002	128	1130	73.06	3.00	72.37	8.53	57.37
15.	10g	N+F+P.L.+ T.vi. (T_{15})	2175	206	2381	43.25	6.07	44.10	13.38	33.13
	20g	N+F+P.L.+ T.vi. (T_{15})	1878	182	2060	50.90	5.23	51.84	12.02	39.93
16.	10g	N+F+P.L.+ T.ha (T_{16})	1342	148	1490	64.48	3.90	64.08	10.49	47.57
	20g	N+F+P.L.+ T.ha (T_{16})	1108	139	1247	70.28	3.42	68.50	9.18	54.12
17.	10g	Sorghum straw alone	3108	286	3394	19.11	7.95	26.79	15.17	24.18
18.	20g	Sorghum and teaw alone	3005	268	3273	21.99	7.76	28.54	14.96	25.23
19.		N + F	3701	495	4196		10.86	0.00	20.01	0.00
20.		Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CD at 5%					337.91		0.60		5.14	

T_1 & T_9 = From Jaipur, T_2 & T_{13} = From Chittorgarh, T_3 & T_{14} = From Hardwar,
T_4 T_5 & T_6 & T_{11} = From Aligarh, T_7, T_{12}, T_{15} = From Ag.Co., T_8 = from J.S., T_{10} & T_{16} = from Udaipur.
T.h. = *Trichoderma harzianum* Tha = *Trichoderma hamatum* N = Nematode
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T. vi. = *Trichoderma virens* F = *Fusarium oxysporum* S.S. = *Sorghum* straw

reducing soil borne pathogens[14].

The observations indicated that the pathogen lost their viability after colonization with antagonists. Hyphae of species of *Trichoderma* overpowered the growth of pathogen and entered inside the mycelium of the pathogen. Sometimes the mycelium of the pathogen was also found to be full of antagonist spores. Ultimately, host hyphae shrivelled and got killed. Mukopadhyay[15] also reported mode of parasitism through physical contact, pathogen cell wall lysis and coiling of hyphae.

It is possible that culture of antagonists contained some kind of enzymes or antibiotics responsible for inhibition of conidial germination or suppression of mycelial growth.

Thus, in the process of biological control of the plant pathogens, several mechanisms *viz.*, competition for space and nutrition, parasitism and antibiosis have been reported to be involved. The antagonistic biocontrol agents are reported to produce some volatile and non-volatile metabolites interfering with growth and survival of the pathogens[16, 17].

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