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Management of bacterial blight of cotton caused by *Xanthomonas axonopodis pv. malvacearum*

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ABSTRACT

An experiment was carried out to see the efficacy of different chemicals and bioagents against bacterial blight disease severity (PDI) and disease incidence (PI). Significantly low disease severity and low disease incidence were recorded in treatment T_4 i.e. copper oxychloride 0.25 % + streptocycline 100 ppm sprays to the tune of 11.83 per cent (PDI) and 19.36 per cent (PI) respectively as against the unsprayed control 27.56 per cent and 45.51 per cent respectively and obtained significantly higher seed cotton yield 2567.33 kg/ha followed by carbendazim 0.1 % + streptocycline 100 ppm. Amongst the antagonist tested against *Xanthomonas axonopodis* pv. *malvacearum*, *Trichoderma hamatum* was significantly superior in per cent reduction of mycelia colony diameter (mm) of pathogen at all the incubation periods tested. The next best antagonist noticed was *T. harzianum* and *P. fluorescens*. Per cent reduction in colony diameter (mm) of the pathogen after 3, 6 and 9 days of incubation in *T. hamatum* was noticed to the tune of 50.94, 48.03 and 44.12 per cent, respectively.

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1. Introduction

Cotton (*Gossypium* spp.) is the most extensively cultivated commercial crop and most important of all fibre crops Cotton locally known as “White Gold”. In India, cotton occupies second largest cultivated area followed by sugarcane. In Maharashtra, it is largely grown as rainfed crop and very small area under irrigated condition. India has the largest acreage 95.5 lakh/ha under cotton at global level and has the productivity of 591 kg lint/ha and ranks second in production 332 lakh bales after China during 2008-09 (Anonymous, 2009). In India, main cotton

growing area is seen in the central zone of India comprising of Gujarat, Maharashtra and Madhya Pradesh. Cotton is grown in Maharashtra on an area of 31.24 lakh ha. While, the production is near about 60 lakh bales, with an average productivity of 320 kg lint/ha during 2008-09 (Anonymous, 2009).

Amongst the several factors responsible for reduction in yield and quality deterioration of cotton in India, a disease occupies a vital place. Bacterial blight of cotton caused by *Xanthomonas axonopodis* pv. *malvacearum* is one of the serious diseases of cotton. It is recorded in almost every country in the world which grows cotton. It is an important disease of cotton in India, Pakistan, China, South East Asia, South America, Australia and Europe. (Verma, 1986; Hillocks, 1992). In India, disease observed in Andhra Pradesh, Haryana, Madhya Pradesh, Maharashtra, Punjab, Rajasthan and Tamil Nadu (Verma, 1986; and Srinivasan, 1994). In India, estimates of losses are often upto 30 per cent (Rampandu *et al*. 1979; Meshram *et al*., 1988 and 1992; Patil *et al*., 2003).

Considering the importance of the bacterial blight in cotton cultivation, different measures like use of chemicals and bio-agents have been advocated in past for the management of this disease.

2. Materials and methods

2.1. Management of bacterial blight disease of cotton with chemicals

A field experiment was carried out to study efficacy of different antibacterial pesticides against bacterial blight of cotton with eight treatments in Randomized Block Design (RBD) with variety Bunny Bt (NCS-145). In all eight treatment sprays were undertaken. First spray was undertaken after disease initiation and subsequent sprays at an interval of 15 days. In eight treatments one control (unsprayed) treatment was blight disease to allow developing. Observations on disease incidence and severity were recorded at 30 DAS, 60 DAS, 90 DAS and 120 DAS and also seed cotton yield.

2.2. Efficacy of bioagents against *Xanthomonas axonopodis* pv. *malvacearum*

The antagonistic potential of *Trichoderma* spp. was assessed against *Xanthomonas axonopodis* pv. *malvacearum* by dual culture technique on Yeast Glucose Chalk Agar Medium as per procedure. For this 20 ml of sterilized and luke warm medium chalk agar was poured in each petriplate and allowed to solidify. With the help of sterile inoculating needle streak the bacterial culture on half side of petriplate and other side *Trichoderma* spp. were inoculated. Control i.e. without inoculation of the bio-agent was maintained simultaneously. Observation regarding colony radius of *Xanthomonas* and bio-agent were recorded at 3, 6, 9 days after inoculation by incubating at 27 $\pm$ 2^{o}C temperature.

2.3. Efficacy of chemicals against *Xanthomonas axonopodis* pv. *malvacearum*

Solutions of desired concentrations of chemicals and their combination were prepared in a sterile distilled water. Discs of 5 mm diameter were cut from Whatman No.1 filter paper and sterilized. Those were then saturated with the solution. Excess solution was drained off by touching the discs inside dry surface of plate holing the solution and then placed on the agar surface of inoculated plate. Seven discs of each chemical were then incubated at 27^{o}C$\pm$2^{o}C for 72 hrs. Diameter of zone of the inhibition was measured.

The observations of growth parameters were also used for statistical analysis. To compare two treatment means, critical difference (C.D.) at 5 % level of significance was worked out.

3. Results and discussion

3.1. Management of bacterial blight disease of cotton with chemicals

A field experiment had eight spray treatments which included six chemical, one biological and one water spray (control). In all eight treatments sprays starting from disease initiation (30 DAS) were applied and subsequent sprays at an interval of 15 days were given and observation on disease incidence and disease severity were recorded at 30 days, 60 days, 90 days and 120 days after sowing.

3.2. Disease indence (DI)

Data on disease incidence is presented in Table**.** Results on disease incidence were significant at 30, 60, 90 and 120 DAS. All the treatments recorded significantly low disease incidence over control at 30, 60, 90 and 120 DAS. Mean per cent disease incidence ranged from 19.36 to 45.51 per cent.

Disease incidence after 30 days of sowing was found significant over control and ranged from 16.93 to 23.27 per cent against 26.43 per cent in control plot. Treatment T_4 i.e. copper oxychloride (0.25 %) + streptocycline (100 ppm) was significantly superior over rest of the treatments. Minimum disease incidence 16.93 per cent was observed in T_4 treatment and which was at par with carbendazim 80.1 % + streptocycline 100 ppm (17.76 per cent) and carbendazim 0.1 % (17.41 per cent).

Disease incidence after 60 days of sowing was found significant over control and ranged from 21.80 to 40.47 per cent as against 49.11 per cent in control plot. The minimum disease incidence 21.80 per cent was found in fungicide copper oxychloride 0.25 % + agrimycin 100 ppm followed by carbendazim 0.1 % + streptocycline 100 ppm (27.25 per cent) and copper oxychloride 0.25 % + streptocycline 100 ppm (28.97 per cent).

At 90 DAS disease incidence was found significant over control and ranged from 16.52 to 30.97 per cent as against 52.32 per cent in control plot. Treamtent T_4 i.e. copper oxychloride (0.25 %) + streptocycline (100 ppm) was significantly superior over rest of the treatments. Minimum disease incidence 16.52 per cent was observed in T_4 treatment followed by carbendazim 0.1 % + streptocycline 100 ppm (20.15 per cent) and copper oxychloride 0.25 % + agrimycin 100 ppm (23.90 per cent).

At 120 DAS, disease incidence was found significant over control and ranged from 15.04 to 27.47 per cent as against 54.18 per cent in control plot. The minimum disease incidence 15.04 per cent was found in fungicide copper oxychloride 0.25 per cent + streptocycline 100 ppm followed by carbendazim 0.1 % + streptocycline 100 ppm (18.33 per cent), copper oxychloride 0.25 % + agrimycin 100 ppm (20.92 per cent) and carbendazim 0.1 % (23.84 per cent).

Table 1

Effect of different treatments on bacterial blight incidence of cotton

Tr. No.	Treatment details	Per cent disease incidence (PI)				Mean PI
		30 DAS	60 DAS	90 DAS	120 DAS	
T1	Carbendazim (Bavistin) 0.1 %	17.41	30.94	26.84	23.84	24.76
		(24.64)	(33.77)	(31.19)	(29.21)	(29.70)
T2	Copper oxychloride (Blue	23.12	37.04	30.15	27.68	29.50
	copper) 0.25 %	(28.72)	(37.48)	(33.29)	(31.73)	(32.80)
T3	Streptocycline 100 ppm	21.80	40.47	33.04	31.74	31.76
		(27.79)	(39.50)	(35.07)	(34.28)	(34.16)
T4	Copper oxychloride 0.25 % +	16.93	28.97	16.52	15.04	19.36
	Streptocycline 100 ppm	(24.25)	(32.55)	(23.96)	(22.80)	(25.89)
T5	Carbendazim 0.1 % +	17.76	27.25	20.15	18.33	20.87
	Streptocycline 100 ppm	(24.90)	(31.45)	(26.64)	(25.34)	(27.07)
T6	Copper oxychloride 0.25 % +	23.27	21.80	23.90	20.92	22.47
	Agrimycin 100 ppm	(28.82)	(27.81)	(29.24)	(27.21)	(28.27)
T7	*Psuedomonas fluorescens* 0.2 %	25.38	48.24	30.97	27.47	33.01
		(30.23)	(43.98)	(33.80)	(31.60)	(34.90)
T8	Control (Water spray)	26.43	49.11	52.32	54.18	45.51
		(30.92)	(44.48)	(46.32)	(47.39)	(42.27)
	SE $\pm$	0.59	0.73	0.72	0.34	
	CD at 5%	1.78	2.22	2.18	1.04	

3.3. Disease severity (PDI)

Data on disease severity is presented in Table 2. The results on disease severity were significant over control at 30, 60, 90 and 120 DAS. Mean per cent disease severity ranged from 11.83 per cent to 27.56 per cent.

Disease severity after 30 days of sowing was found significant over control and ranged from 10.25 to 13.20 per cent as against 16.00 per cent in control plot. Treatment T_4 i.e. copper oxychloride (0.25 %) + streptocycline (100 ppm) found significantly superior over rest of the treatments. Minimum disease severity 10.25 per cent was

observed in T_4 treatment and which was at par with carbendazim 0.1 % + streptocyline 100 ppm (10.75 per cent) and carbendazim 0.1 % (10.54 per cent).

Table 2
Effect of different treatments on bacterial blight intensity of cotton

Tr. No.	Treatment details	Per cent disease intensity (PDI)				Mean PDI
		30 DAS	60 DAS	90 DAS	120 DAS	
T1	Carbendazim (Bavistin) 0.1 %	10.54	18.73	16.25	9.75	13.81
		(18.79)	(25.62)	(23.74)	(18.13)	(21.57)
T2	Copper oxychloride (Blue copper)	14.00	22.42	18.25	12.25	16.73
	0.25 %	(21.94)	(28.25)	(25.27)	(20.46)	(23.98)
T3	Streptocycline 100 ppm	13.2	24.50	20.00	11.22	17.23
		(21.29)	(29.60)	926.54)	(19.52)	(24.23)
T4	Copper oxychloride 0.25 % +	10.25	17.54	10.00	9.55	11.83
	Streptocycline 100 ppm	(18.64)	(24.74)	(18.35)	(17.95)	(19.92)
T5	Carbendazim 0.1 % +	10.75	16.50	12.20	8.35	11.95
	Streptocycline 100 ppm	(19.07)	(23.92)	(20.40)	(16.76)	(29.04)
T6	Copper oxychloride 0.25 % +	14.09	19.25	14.47	11.27	14.77
	Agrimycin 100 ppm	(22.03)	(26.01)	(22.32)	(19.56)	(22.48)
T7	*Psuedomonas fluorescens* 0.2 %	15.30	29.20	18.75	13.15	19.25
		(23.01)	(32.68)	(25.63)	(21.24)	(25.64)
T8	Control (Water spray)	16.00	29.73	31.34	33.19	27.56
		(23.56)	(33.02)	(34.01)	(35.16)	(31.48)
	SE $\pm$	0.76	0.60	1.06	0.73	
	CD at 5%	2.31	1.84	3.22	2.23	

Disease severity after 60 days of sowing was found significant over control and ranged from 16.50 to 24.50 per cent. The minimum disease intensity or severity 16.50 per cent was found in fungicide carbendazim 0.1 % + streptocycline 100 ppm followed by copper oxychloride 0.25 % + streptocycline 100 ppm (17.54 per cent), carbendazim 0.1 % (18.73 per cent) and copper oxychloride 0.25 % + Agrimycin 100 ppm (19.25 per cent).

At 90 DAS disease severity was found significant over control and ranged from 10.00 to 18.75 per cent as against 31.34 per cent in control plot. The treatment T_4 i.e. copper oxychloride (0.25 %) + streptocycline (100 ppm) found significantly superior over rest of the treatments. Minimum disease severity 10 % was observed in T_4 treatment followed by carbendazim 0.1 % + streptocycline 100 ppm (12.20 per cent), copper oxychloride 0.25 % + agrimycin 100 ppm (14.47 per cent) and carbendazim 0.1 % (16.25 per cent).

At 120 DAS, disease severity was found significant over control and ranged from 8.35 to 13.15 per cent as against 33.19 per cent in control plot. The minimum disease severity 8.35 per cent was found in T_5 treatment i.e. carbendazim 0.1 % + streptocycline 100 ppm followed by copper oxychloride 0.25 % + streptocycline 100 ppm (9.55 per cent), carbendazim 0.1 % (9.75 per cent) and streptocycline 100 ppm (11.22 per cent).

Data on per cent disease control is presented in Table 3. Data clearly indicated that disease control after each spray was significantly influenced. Per cent disease control after first and second spraying was ranged from 4.37 to 35.93 and 40.17 to 68.09 per cent, respectively. After third spraying maximum disease control was recorded in fungicide copper oxychloride 0.25 % + streptocycline 100 ppm to the tune of 74.84 per cent Disease severity after 60 days of sowing was found significant over control and ranged from 16.50 to 24.50 per cent. The minimum disease intensity or severity 16.50 per cent followed by carbendazim 0.1 % + streptocycline 100 ppm (71.22 %) and carbendazim 0.1 % (70.62 %).

Mean disease control (Table 3) achieved with all the treatments ranged from 34.97 to 59.62 per cent. The highest mean disease control of 59.62 per cent recorded in fungicide copper oxychloride 0.25 % + streptocycline 100 ppm. The second and third best fungicides were carbnedazim 0.1 % + streptocycline 100 ppm (55.03 %) and carbendazim 0.1 % (50.96 %).

Results obtained in respect of the efficacy of fungicides and bactericides in effectively controlling the bacterial blight disease of cotton are in conformity with those reported earlier in cotton by Singh and

Singh (1988), Shah *et al*. (1991), Meshram *et al*. (1985), Jeyachandran and Shanmugam (1979), Thind and Mehara (1992), Patil *et al*. (1997), Islam *et al*. (2003) and Govindappa *et al*. (2008).

Table 3

Effect of different treatments on disease intensity

Tr. No.	Treatment details	PDI after spraying			Mean PDI	PDC after spraying			Mean PDC
		I	II	III		I	II	III	
T1	Carbendazim (Bavistin) 0.1 %	10.54 (18.79)	16.25 (23.74)	9.75 (18.13)	12.18	34.12	48.14	70.62	50.96
T2	Copper oxychloride (Blue copper) 0.25 %	14.00 (21.94)	18.25 (25.27)	12.25 (20.46)	14.83	12.50	41.76	63.09	39.11
T3	Streptocycline 100 ppm	13.2 (21.29)	20.00 (26.54)	11.22 (19.52)	14.80	17.50	36.18	66.19	39.95
T4	Copper oxychloride 0.25 % + Streptocycline 100 ppm	10.25 (18.64)	10.00 (18.35)	9.55 (17.95)	9.93	35.93	68.09	74.84	59.62
T5	Carbendazim 0.1 % + Streptocycline 100 ppm	10.75 (19.07)	12.20 (20.40)	8.35 (16.76)	10.43	32.81	61.07	71.22	55.03
T6	Copper oxychloride 0.25 % + Agrimycin 100 ppm	14.09 (22.03)	14.47 (22.32)	11.27 (19.56)	13.27	11.93	53.82	66.04	43.93
T7	*Psuedomonas fluorescens* 0.2 %	15.30 (23.01)	18.75 (25.63)	13.15 (21.24)	15.73	4.37	40.17	60.37	34.97
T8	Control (Water spray)	16.00 (23.56)	31.34 (34.01)	33.19 (35.16)	26.84				
	SE $\pm$	0.76	1.06	0.73					
	CD at 5%	2.31	3.22	2.23					

3.4. Seed cotton yield

Data on seed cotton yield is presented in Table 4. Result of different chemical treatment on the seed cotton yield was found significant over control and ranged from 2567.33 to 1456 kg/ha as against 1181.33 kg/ha seed cotton yield in control plot. The treatment T_4 i.e. copper oxychloride 0.25 % + streptocycline 100 ppm found significantly superior over rest of the treatments. Maximum seed cotton yield 2567.33 kg/ha was observed in T_4 treatment followed by carbendazim 0.1 % + streptocycline 100 ppm 92456.75 kg/ha), carbendazim 0.1 % (2070.33 kg/ha) and copper oxychloride 0.25 % + agrimycin 100 ppm (2030.33 kg/ha). Mean per cent disease intensity found significant over control (27.56 %). The lowest mean per cent disease severity 11.83 per cent was observed in T_4 treatment i.e. copper oxychloride 0.25 % + streptocycline 100 ppm followed by carbendazim 0.1 % + strpetocycline 100 ppm (11.95 per cent), carbendazim 0.1 % (13.81 per cent) and copper oxychloride 0.25% + agrimycin 100 ppm (14.77 per cent). Mean per cent disease incidence found significant over control (45.51 per cent). The lowest mean per cent disease incidence 19.36 per cent was observed in T_4 treatment i.e. copper oxychloride 0.25 % + streptocycline 100 ppm followed by carbendazim 0.1 % + streptocycline 100 ppm (20.87 per cent) and copper oxychloride 0.25 % + agrimycin 100 ppm 922.47 per cent). Results obtained in respect of the efficacy of chemicals in effectively controlling the bacterial blight disease of cotton and increasing seed cotton yield are in conformity with those reported earlier in cotton by Meshram *et al*. (1988) a and b, Meshram *et al*. (1992), Poswal (1993), Mishra *et al*. (2001) and Sandhu *et al*. (2002).

3.5. Management of bacterial blight disease of cotton with bioagents *in vitro*

Five different species of *Trichoderma viz.*, *Trichoderma viride*, *T. hamatum*, *T. harzianum*, *T. lignorum*, *T. koningii* and one bacterial origin bioagent i.e. *P. fluorescens* were tested as biological agents for the control of *Xanthomonas axonopodis* pv. *malvacearum*. The effect of bioagents tested against *Xanthomonas axonopodis* pv. *malvacearum* by dual culture technique are given in Table 5, 6 and 7. The mycelial growth of the pathogen and antagonist was recorded at 3, 6 and 9 days of incubation and per cent reduction in colony diameter (mm) of pathogen over control was calculated. At 3 days of incubation all the species of *Trichoderma* except *T. viride* and *T. lignorum* reduced the growth of *X. axonopodis* pv. *malvacearum* over control. The maximum reduction of the pathogen was observed with *Trichoderma hamatum* (50.94 per cent) followed by *Trichoderma harzianum* (33.58 per cent) and *P. fluorescens* (33.52 per cent). Amongst antagonists maximum growth was observed with *T. harzianum* (28.07 mm) followed by *P. fluorescens* (25.79 mm) and *T. hamatum* (23.57 mm). At 6 days of incubation all the species of *Trichoderma* except *T. lignorum* reduced the growth of pathogen over control. The maximum reduction of the pathogen was observed with *T. hamatum* (48.03 per cent) followed by *T. harzianum* (40.39 per cent) and *P. fluorescens* (43.72 per cent). Amongst antagonists maximum growth was observed with *T. hamatum* (55.85 mm) followed by *P. fluorescens* (50.60 mm) and *T. harzianum* (49.70 mm). At 90 days of incubation all the species of *Trichoderma* reduced the growth of pathogen over control. The maximum reduction of the pathogen was observed with *T. hamatum* (44.12 per cent) followed by *T. harzianum* (41.70 per cent) and *P. fluorescens* (41.02 per cent). Amongst the antagonists maximum growth was observed with *T. hamatum* (60.73 mm) followed by *P. fluorescens* (58.85 mm) and *T. harzianum* (56.91 mm). Considering the per cent reduction of colony diameter (mm) of the pathogen over control after 3, 6 and 9 days incubation period (Table 8) the treatment *T. hamatum* was found best followed by *T. harzianum* and *P. fluorescens*. Results obtained in respect of efficacy of bioagent in effectively inhibiting the *Xanthomonas* are in conformity with those reported earlier by Chattannovar *et al*. (1988), Sujoy-Saha *et al*. (2000), Sanjay-Arya *et al*. (2002), Saha *et al*. (2003), Manmeet Manav *et al*. (2002), , Nzojiyobiri *et al*. (2003) and Patil *et al*. (2004).

3.6. Efficacy of different chemicals against *Xanthomonas axonopodis* pv. *malvacearum*

Efficacy of different chemicals *in vitro* was evaluated against the *Xanthomonas axonopodis* pv. *malvacearum*. The data from Table 9 clearly showed that the maximum mean inhibition was in the treatment T_4 i.e. copper oxychloride 0.25 % + streptocycline 100 ppm (18.33 mm) of T_1 carbendazim 0.1 % and T_5 carbendazim 0.1 % + streptocycline 100 ppm were at par to each other (15.00 mm). It was followed by inhibition obtained with treatment T_6 copper oxychloride 0.25 % + Agrimycin 100 ppm (14.33 mm), T_7 Pseudomonas fluorescens 0.2 % (14.00 mm). The minimum mean inhibition zone was found in the treatment T_2 copper oxychloride (10 mm). The maximum per cent inhibition found in treatment T_4 copper oxychloride 0.25 % + streptocycline 100 ppm (20.36 %) and the minimum per cent inhibition was found in the treatment T_2 copper oxychloride (0.25 %). The results in the present investigation are agreement with those reported in the past. Verma (1975) observed better inhibition concentration of streptomycin sulphate, agrimycin 100 ppm, blitox (copper oxychloride) were 2.5, 25, 30 and 50 ppm respectively under *in vitro* conditions. Shah *et al.* (1991) observed maximum inhibition by streptocycline (75%) followed by streptocycline + copper oxychloride (64%).

4. Conclusion

Biological control is an effective, ecofriendly and alternative approach for any disease management practice. The results on *Xanthomonas axonopodis* pv. *malvacearum,* revealed that, all the chemicals and antagonists significantly reduced the growth of *X. axonopodis,* either by over growing or by exhibiting inhibition zones. Most of antagonists inhibited colony growth of *X. axonopodis,* by their fast and over growing nature as observed in antagonists. Similarly Deshmukh and Raut (1992) reported that *Trichoderma harzianum* Rifai and *T. viride* Pers. overgrew colonies of *C. gloeosporioides* and *T. harzianum* was more aggressive than *T. viride*. Santha Kumari (2002) observed that the isolates of T1 and T2 of *T. harzianum* and the isolates of A1 and A2 of *Aspergillus niger* were found effective in inhibiting the growth of *C. gloeosporioides* causing anthracnose of black pepper under in vitro condition. This can be attributed to higher competitive ability of this *Trichoderma* spp. The antagonism of *Trichoderma* spp. against many fungi is mainly due to production at acetaldehyde compound (Robinson and Park, 1966 and Dennis and Webster, 1971). This may also be the reason for its antagonistic effect on *X. axonopodis*. Godtfredsen and Vagedal (1965) reported trichodermin, Pyke and Dictz (1960) found dermadin as major volatile antibiotic produced by *Trichoderma* spp., which suppress several plant pathogens.

Table 4

Effect of different treatments on bacterial blight disease intensity, incidence and seed cotton yield.

Tr. No.	Treatment details	Mean PDI	Mean PI	Seed cotton yield (kg/ha)
T1	Carbendazim (Bavistin) 0.1 %	13.81 (21.57)	24.76 (29.70)	2070.33
T2	Copper oxychloride (Blue copper) 0.25 %	16.73 (23.98)	29.50 (32.80)	1610.50
T3	Streptocycline 100 ppm	17.23 (24.23)	31.76 (34.16)	1517.67
T4	Copper oxychloride 0.25 % + Streptocycline 100 ppm	11.83 (19.92)	19.36 (25.89)	2567.33
T5	Carbendazim 0.1 % + Streptocycline 100 ppm	11.95 (29.04)	20.87 (27.07)	2456.75
T6	Copper oxychloride 0.25 % + Agrimycin 100 ppm	14.77 (22.48)	22.47 (28.27)	2030.33
T7	*Psuedomonas fluorescens* 0.2 %	19.25 (25.64)	33.01 (34.90)	1456.00
T8	Control (Water spray)	27.56 (31.48)	45.51 (42.27)	1181.33
	SE ±			134.29
	CD at 5%			406.72

Table 5

Mean colony diameter (mm) at 3 days.

Sr. No.	Antagonists	Mean colony diameter (mm) at 3 days		
		Pathogen	Antagonist	Per cent reduction of colony diameter over control
T1	*T. viride*	16.93	13.51	-6.28
T2	*T. hamatum*	7.80	23.57	50.94
T3	*T. harzianum*	10.56	28.07	33.58
T4	*T. lignorum*	19.53	11.94	-22.83
T5	*T. koningii*	12.57	19.94	20.94
T6	*P.fluorescens*	10.57	25.79	33.52
T7	Control	15.90	--	--
	SE ±	0.75	0.71	
	CD at 5%	2.24	2.11	
	CV %	11.29	6.73	

Table 6

Mean colony diameter (mm) at 6 days.

Sr. No.	Antagonists	Mean colony diameter (mm) at 6 days		
		Pathogen	Antagonist	Per cent reduction of colony diameter over control
T1	*T. viride*	30.56	18.01	21.50
T2	*T. hamatum*	20.23	55.85	48.03
T3	*T. harzianum*	20.87	49.70	46.39
T4	*T. lignorum*	40.56	34.21	-4.19
T5	*T. koningii*	27.20	31.61	30.13
T6	*P.fluorescens*	21.91	50.60	43.72
T7	Control	38.93	--	
	SE ±	1.05	0.78	
	CD at 5%	3.13	2.34	
	CV %	7.38	3.78	

Table 7

Mean colony diameter (mm) at 9 days.

Sr. No.	Antagonists	Mean colony diameter (mm) at 9 days		
		Pathogen	Antagonist	Per cent reduction of colony diameter over control
T1	*T. viride*	35.67	50.93	16.28
T2	*T. hamatum*	23.81	60.73	44.12
T3	*T. harzianum*	24.84	56.91	41.70
T4	*T. lignorum*	41.95	43.67	1.55
T5	*T. koningii*	30.78	54.82	27.76
T6	*P.fluorescens*	25.13	58.85	41.02
T7	Control	42.61	--	
	SE ±	0.53	0.78	
	CD at 5%	1.59	0.33	
	CV %	3.34	2.88	

Table 8

Percent reduction in colony diameter of the pathogen over control

Sr. No.	Antagonists	Days after incubation		
		3	6	9
T1	*T. viride*	-6.48	21.50	16.28
T2	*T. hamatum*	50.94	48.03	44.12
T3	*T. harzianum*	33.58	46.39	41.70
T4	*T. lignorum*	-22.83	-4.19	1.55
T5	*T. koningii*	20.94	30.13	27.76
T6	*P.fluorescens*	33.52	43.72	41.02

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