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Bawane Atul Suresh
Department of Plant Pathology, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Sunil Zacharia
Department of Plant Pathology, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Seyoun Raj Kar
Department of Plant Pathology, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Bawane Atul Suresh
Department of Plant Pathology, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Eco-friendly management of chickpea wilt *Fusarium oxysporum* f. sp. *ciceri* (Schlecht & Emend Synd. & Hans.)

Bawane Atul Suresh, Sunil Zacharia and Seyoun Raj Kar

Abstract
Chickpea is affected by many diseases, among which Fusarium wilt (*Fusarium oxysporum* f.sp. *ciceri*) is the most important disease which causes yield losses up to 77-94%. In present investigation tests were carried out for the management of fusarium wilt using botanicals, organic amendments, bio-agent and a fungicide (treated check). Treatments were evaluated in-vitro and in-vivo in plants against fusarium wilt and readings were taken at 30, 60 and 90 DAS for growth parameters and the percentage of disease incidence were calculated. Among the treatments, soil application with *Trichoderma viride* were found most effective in the percentage of disease control in chickpea. Followed by Neem cake as compared to Carbendazim (treated check) and control. The maximum plant height, dry shoot weight, dry root weight and yield were found in *Trichoderma viride* treated plants as well as. Thus, fusarium wilt could be managed by the integrated of various approach like, soil application of bio-agent and soil amendment.

Keywords: Bio-agents, botanicals, chickpea, *Fusarium oxysporum* f. sp. *ciceri*, organic amendments, fungicide

Introduction
Chickpea (*Cicer arietinum* L.) is a major pulse crop of India, grown in diverse agro-climatic conditions. It is a native of the Mediterranean region and commonly known as Gram or *Bengal gram* is the most important pulse crop used for human consumption as dal, vegetable etc. and straw as animal fodder. It is a highly nutritious grain legume crop and it is a rich source of protein, vitamins and minerals containing 17-22% protein, 60-64% carbohydrate and 3-4% fat with a good source of phosphorus, calcium and other potentially health beneficial phyto-chemicals (Sindhu *et al.*, 1974) [23].

This crop is grown in temperate as well as sub-tropical regions of the world. It play vital role in fixing atmospheric nitrogen in soil and thus improves the soil fertility and conserve the natural resources which are essential for sustainable agriculture. The crop can be grown as a second crop using residual moisture. The production of chickpeas in India was 9.09 million tonnes, led by India with 67% of the global total production of 14.8 million tons (FAO report 2017) [9]. The major chickpea growing states Maharashtra, Madhya Pradesh, Uttar Pradesh, Gujarat, Telangana, Rajasthan, Andra Pradesh and Karnataka. The production of chickpea in Uttar Pradesh was 1.01t/ha (Anonymous 2015).

Several biotic and abiotic factors are responsible for low productivity of chickpea. Among which soil borne pathogen play important role for reduction in crop productivity and it is cultivated in rainfed condition (Gupta *et al.*, 1987) [10]. Fusarial wilt reduces chickpea production by decreasing both seed yield and seed weight and yearly yield losses from the disease were roughly estimated at 10 to 15% in India. Early wilting is reported to cause more yield loss (77 to 94%) than late wilting (24 to 65%). The seeds which were obtained from late-wilted plants are lighter, rougher, and duller than those from healthy ones (Jimenez-Diaz *et al*., 2015) [13].

Wilt is one of the major soil / seed borne disease of chickpea (*C. arietinum* L.). The pathogen is both seed and soil borne, facultative saprophyte and can survive and in soil up to six years in the absence of a susceptible host (Haware *et al*., 1978 and 1986) [11, 12]. The spores of fungus enters the vascular system of plant via the roots. It produces enzymes that obstruct cell wall and block the plant's transport system. Discoloration of the internal tissues progresses from roots to the Ariel parts of the plant. That causes chlorosis of leaves and shrunken stems both above and below ground level ultimately leads to the death of plant (Brayford, 1998; Leslie and Summerell *et al*., 2006) [8].

Bio-agent and botanicals belonging to various groups recommended for the management of fusarial wilt. Generally farmers are using only the chemicals for managing the disease, but it has negative impact on the environment as well as develops resistant in the pathogen. Considering the effects of this disease, the present paper discusses the efficacy of *Trichoderma* sp. and botanicals for the management of fusarial wilt.

Materials and Methods

Preparation of Plant extracts

Fresh plant samples were washed in tap water and finally washed thrice using sterilized distilled water. They were crushed in a sterilized pestle and mortar by adding little quantity of alcohol (1:1 w/v) just enough to moisten the samples so that it was easy to crush. The extracts were strained through the two layers of muslin cloth. Finally, filtrates thus obtained from the leaves were used as stock solution.

Poison food technique

Five millimeter diameter disc of fusarium wilt were kept at the centre of each Petri plate containing the required concentration of botanicals and fungicide dissolved in PDA. Three replications were maintained. The plates were incubated at 27±1 °C for seven days and colony diameter were recorded. Per cent inhibitions of mycelia growth were calculated by using the formula given by (Vincent 1947) [26].
Per cent inhibition were calculated by using the formula given by (Vincent 1947) [26].

$$I = \frac{C - T}{C} \times 100$$

Where,
Per cent reduction growth of test pathogen
I = Per cent reduction in growth of test pathogen
C = Radial growth (mm) in control
T= Radial growth (mm) in treatment

Experimental detail

The Field experiment were conducted at the Department of Plant Pathology, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during *Rabi* season (2019-2020). The site selected were uniform, cultivable with typical sandy loam soil having good drainage. The site of experiment is located at an elevation of 98m above the sea level at 25.87°N latitude and 81.25 °E longitudes. The region is located in the south-eastern part of Uttar Pradesh and has subtropical climate with extreme of summer and winter. During the winter season especially during December and January, the temperature drops down to as low as 1 °C while during the summer temperature reaches up to 48-50 °C. The average rainfall in area was around 1013.4 mm annually and maximum concentration during July to September with a few occasions of shower and drizzles in winter also. The soil type of experimental site was sandy loam, low in organic carbon, nitrogen and phosphorus.

Observation recorded

The observation were recorded 30, 60 and 90 days after sowing.

1. Plant heights (cm).
2. Disease incidence of fusarium wilt (%).
3. Dry shoot weight (gm).
4. Dry root weight (gm).
5. Yield (t/ha).

Cost Benefit Ratio

Cost Benefit ratio is the ratio of gross return to cost of cultivation, which can also be expressed as return per rupee invested. This index provides an estimate of the benefit a farmer derives from the expenditure he incurs in adopting a particular cropping system. Any value above 2.0 is considered safe as the farmer gets Rs. 2 for every rupee invested. The cost benefit ratio were calculated using the formula (Reddy and Reddy, 2004) [21].

$$\text{CBR} = \frac{\text{Gross Return (Rs/ha)}}{\text{Total cost of cultivation (Rs/ha)}}$$

Result and Discussion

Effect of plant extract and fungicide against radial growth and percent mycelial inhibition of fusarium wilt (*in vitro*)

Efficacy of different two plant extract and one fungicide at three different concentrations *viz*. 5, 10 and 15 per cent were tested against fusarium wilt in vitro condition by using poisoned food technique. The observations among the three concentration the radial growth of test fungus is high (54mm) at 5% concentration of datura, while the growth of fungus is less (39mm) at 15% concentration at ashwagandha. The minimum radial growth were recorded in ashwagandha at 5%, 10% and 15% conc. were 46mm, 42mm and 39mm respectively.
Efficacy of datura, ashwagandha and carbendazim at three different concentrations (5%, 10%, and 15%) were evaluated against mycelial inhibition of fusarium wilt by poisoned food technique. While ashwagandha show maximum inhibition at 15%, 10% and 5% concentrations inhibits 54.65%, 51.16% and 46.51% respectively. While datura show least inhibition at 15%, 10% and 5% concentrations inhibits 47.67%, 41.86% and 37.20% respectively of test fungus. The maximum percent mycelial inhibition were found in ashwagandha at 5%, 10% and 15% concentrations were 46.51%, 51.16% and 54.65% respectively. Which were similar to the finding by (Vani *et al.* 2019) [25]. In the studies conducted by (Vani *et al.* 2019) [25] the percent mycelial inhibition were found in ashwagandha at 5%, 10% and 15% concentrations were 46.3%, 47.6% and 54.5% respectively shown in Table 1.

Field evaluation

Effect of treatments on plant height, dry shoot weight and dry root weight: The observations were recorded at 30, 60 and 90 DAS. Maximum plant height (cm) at 90 DAS were recorded with *Trichoderma viride* (36.59cm) followed by ashwagandha (34.04cm), neem cake (33.34cm) shown in Table 2. Maximum dry shoot weight (g) at 90 DAS were recorded with *Trichoderma viride* (8.11g) followed by neem cake (7.81g), mahua cake (7.44g) shown in Table 3. Maximum dry root weight (g) at 90 DAS were recorded with *Trichoderma viride* (1.51g) followed by neem cake (1.30g), mahua cake (1.22g) shown in Table 4. In the present studies highest dry shoot weight and dry root weight at 30, 60 and 90 DAS were recorded in *Trichoderma viride* followed by neem cake were effective over other treatments. This results were similar to the finding of (Animisha *et al.* 2012) [4] in that the highest dry shoot weight and dry root weight were found in *Trichoderma viride* and were effective over other treatments.

Effect of treatments on percent disease incidence and yield

The minimum percent disease incidence (%) at 30 DAS was recorded with *Trichoderma viride* (4.31%) followed by neem cake (8.88%), castor cake (9.30%). Minimum percent disease incidence (%) at 60 DAS were recorded with *Trichoderma viride* (8.39%) followed by neem cake (12.38%), mahua cake (13.86%). Minimum percent disease incidence (%) at 90 DAS were recorded with *Trichoderma viride* (13.90%) followed by neem cake (19.51%), castor cake (21.43%) shown in Table 5. Maximum yield (t/ha) were recorded with *Trichoderma viride* (1.492t) followed by neem cake (1.320t), mahua cake (1.254t) shown in Table 6.

In the present studies minimum disease incidence at 30, 60 and 90 DAS were recorded with *Trichoderma viride* followed by neem cake and found effective over other treatment. These results were similar to the findings of Nikam *et al.* (2007) [17], Andrabi *et al.* (2011) [3], Patra *et al.* (2017) [19] and Mukesh *et al.* (2017) [15]. In the studies conducted by Nikam *et al.* (2007) [17], minimum disease incidence were found with *Trichoderma viride* through soil application were 19.04% and effective over other treatments. In Andrabi *et al.* (2011) [3] the minimum disease incidence were found with *Trichoderma viride* were 9.24%. In the studies conducted by Patra *et al.* (2017) [19] and Mukesh *et al.* (2017) [15], minimum disease incidence were found with neem cake were 11.23% and 20.19% respectively and effective over other treatments.

Table 1: Effect of plant extract and fungicide on radial growth and percent mycelial inhibition of Fusarium wilt.

Treatment No.	Treatment details	Radial growth (mm)				Percent mycelial inhibition (%)			
		5%	10%	15%	Mean	5%	10%	15%	Mean
T_7	Datura	54	50	45	49.667	37.20	41.86	47.67	42.243
T_6	Ashwagandha	46	42	39	42.337	46.51	51.16	54.65	50.773
T_2	Carbendazim	19	16	12	15.667	77.90	81.39	86.04	81.777
T_0	Control	86	86	86	86.000	0	0	0	0
Mean		51.25	48.5	45.5		40.40	43.60	47.09	
								S.Em.	C.D. (0.05)
Treatment								1.584	2.000
Concentration								1.120	3.431
Int. (T X C)								2.241	6.862

*Average of three replicates

Table 2: Effect of treatments on Plant height (cm)

Treatment No.	Treatment detail	Plant height (cm)*			
		30 DAS	60 DAS	90 DAS	Mean
T_0	Control	6.92	14.76	28.59	16.757
T_1	*Trichoderma viride*	7.13	18.41	36.59	20.710
T_2	Carbendazim	7.39	20.70	38.62	22.237
T_3	Neem cake	7.05	16.24	33.34	18.877
T_4	Mahua cake	7.07	16.34	33.02	18.810
T_5	Castor cake	7.15	16.24	33.28	18.890
T_6	Ashwagandha	7.05	16.24	34.04	19.110
T_7	Datura	7.08	16.28	33.22	18.860
CD(p=0.05)		0.219	0.345	0.354	2.561
S.Ed±		0.101	0.159	0.163	1.183

*Average of five plants

Table 3: Effect of treatments on Dry shoot weight (g)

Treatment No.	Treatment detail	Dry shoot weight (g)*			
		30 DAS	60 DAS	90 DAS	Mean
T_0	Control	0.95	1.92	3.92	2.263
T_1	*Trichoderma viride*	2.53	4.11	8.11	4.917
T_2	Carbendazim	2.43	4.07	8.16	4.887
T_3	Neem cake	2.24	3.84	7.81	4.630
T_4	Mahua cake	2.06	3.42	7.44	4.307
T_5	Castor cake	1.96	3.22	7.29	4.157
T_6	Ashwagandha	2.02	3.64	7.18	4.280
T_7	Datura	1.97	3.51	7.31	4.263
CD(p=0.05)		0.011	0.018	0.030	0.838
S.Ed±		0.005	0.008	0.014	0.387

*Average of three plants

Table 4: Effect of treatments on Dry root weight (g)

Treatment No.	Treatment detail	Dry root weight (g)*			
		30 DAS	60 DAS	90 DAS	Mean
T_0	Control	0.12	0.25	0.86	0.410
T_1	*Trichoderma viride*	0.40	0.81	1.51	0.907
T_2	Carbendazim	0.36	0.77	1.41	0.847

T_3	Neem cake	0.25	0.58	1.30	0.710
T_4	Mahua cake	0.19	0.50	1.22	0.637
T_5	Castor cake	0.17	0.42	1.21	0.600
T_6	Ashwagandha	0.21	0.48	1.21	0.633
T_7	Datura	0.20	0.42	1.20	0.607
CD(p=0.05)		0.011	0.014	0.016	0.115
S.Ed±		0.005	0.006	0.007	0.053

*Average of three plants

Table 5: Effect of treatment on Percent Disease Incidence (%)

Treatment No.	Treatment detail	Percent Disease Incidence (%)*			
		30 DAS	60 DAS	90 DAS	Mean
T_1	*Trichoderma viride*	4.31	8.39	13.90	8.867
T_2	Carbendazim	4.55	8.11	13.15	8.603
T_3	Neem cake	8.88	12.38	19.51	13.590
T_4	Mahua cake	9.52	13.86	21.55	14.977
T_5	Castor cake	9.30	15.11	21.43	15.280
T_6	Ashwagandha	10.13	14.39	22.50	15.673
T_7	Datura	10.86	14.89	22.91	16.220
T_0	Control	15.23	20.20	29.63	21.687
CD(p=0.05)		0.586	0.995	1.381	1.768
S.Ed±		0.271	0.460	0.638	0.816

*Average of three plants

Table 6: Effect of treatments on yield (t/ha)

Treatment No.	Treatment detail	Yield (t/ha)			
		R_1	R_2	R_3	Mean
T_1	*Trichoderma viride*	1.482	1.505	1.490	1.492
T_2	Carbendazim	1.510	1.485	1.532	1.509
T_3	Neem cake	1.345	1.290	1.324	1.320
T_4	Mahua cake	1.270	1.232	1.260	1.254
T_5	Castor cake	1.255	1.220	1.272	1.249
T_6	Ashwagandha	1.245	1.250	1.242	1.246
T_7	Datura	1.240	1.195	1.210	1.215
T_0	Control	1.050	1.085	1.080	1.072
CD(p=0.05)					0.034
S.Ed±					0.016

Conclusion

The present study, it were found that bio- agent *Trichoderma viride* soil application were most effective against fusarium wilt, which causes wilt disease in chickpea. Followed by neem cake and ashwagandha were significantly superior in the treatment. It is advice that farmer should use integrated approach for the management of fusarium wilt initially by seed treatment with *Trichoderma viride* or by soil application. Similarly soil application of neem cake and ashwagandha extract could be used for management of fusarium wilt as organic amendment. By using bio-agent and organic amendment we can avoid use of harmful fungicides and prevent development of resistance in pathogen. Results of the present study were found to be significantly effective under Prayagraj agro-climatic conditions. It may vary with region and climatic conditions, therefore for validation of the results more such trials should be carried out in future.

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