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Research Article

EFFICACY OF *Trichoderma harzianum* ALONE AND ITS INTEGRATION WITH FUNGICIDES AGAINST COLLAR ROT CAUSED BY *Sclerotium rolfsii* IN CHICKPEA

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Abstract- An experiment was conducted on Efficacy of *Trichoderma harzianum* with integration of fungicides collar rot disease of chickpea caused by *Sclerotium rolfsii* in Chhattisgarh region during 2013-14 and 2014-15. Results indicated that the all treatments including *Trichoderma harzianum* were found significantly effective for the prevention of mortality caused by *S. rolfsii* in chickpea. Highest seed germination of 89.12 and 90.93 percent was recorded in treatment T_8 = Carboxin+ thiram @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed with Jaggary @ 10g Kg^{-1} seed followed by T_7 = Hexaconazole @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed with Jaggary @ 10g Kg^{-1} seed during both the year. In case of mortality caused by *S. rolfsii*, most effective treatment was found T_7=Hexaconazole @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed with Jaggary @ 10g Kg^{-1} seed which exhibited minimum mortality. It was significantly lower over rest of the treatments. Maximum grain yield (18.71 Kg and 17.26 Kg $plant^{-1}$) was obtained in treatment T_7 = Hexaconazole @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed with Jaggary @ 10g Kg^{-1} seed during 2013-14 and 2014-15, respectively. In case method of application, most effective method of application was found seed soaking as compare to seed dressing in respect to seed germination, mortality and grain yield during both the years.

Keywords- Collar rot, Chickpea, Fungicides, Integrated disease management, *Sclerotium rolfsii, Trichoderma viride*

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Introduction

Chickpea (*Cicer arietinum* L.), belong to family Fabaceae, is one of the most important pulse crop grown all around the world [1]. Firstly, it was cultivated in south eastern areas of the world but now it is also cultivated in semi-arid regions [2]. It is a rich and cheap source of vegetable protein for human nutrition in the developing countries, particularly in South Asia. In addition to having high protein, it also plays an important role in the management of soil fertility because of having the ability of nitrogen fixation in its root nodules [3]. It's also content, carbohydrate, fibre, phosphorus, calcium, magnesium, iron and zinc and β-carotene. It is free of cholesterol and provides several vitamins and minerals [4]. Therefore, its having is a growing demand in the world especially developing country. In India, chickpea accounts for about 45 percent of total pulses production in the country. In India, it is cultivated in M.P., Rajsthan, U.P., Chhattisgarh, Maharashtra, Andhra Pradesh, Karnataka, Bihar, Haryana, Punjab, Assam, Tamil Nadu etc. Today, 80% of total pulses production is realized in six states namely, Madhya Pradesh, Maharashtra, Rajasthan, Andhra Pradesh, Karnataka and Uttar Pradesh. In India, chickpea crop suffered from many soils borne diseases such as *Fusarium* wilt, dry root rot, collar rot, *Ascochyta blight*, Verticillium wilt, black root rot, Phytophthora root rot, wet root rot, foot rot, Pythium rot and seed rot etc. [5, 6]. Among these, collar rot caused by *Sclerotium rolfsii* is an economically important disease of chickpea. *Sclerotium rolfsii* has been reported on more than 500 species in 100 families in the tropics, subtropics and other warm temperate regions. The most common hosts are legumes, crucifers and cucurbits [7]. Among the soil borne diseases, now day's collar rot caused by *Sclerotium rolfsii* is one of the most devastating soil-borne disease. *Sclerotium rolfsii* is a major cause for mortality (55–95%) of chickpea seedlings. Yield losses from 10 to 30 percent have been recorded annually according which is depending upon the severity of the disease.

It is becoming a serious problem in Chhattisgarh due to the presence of high soil moisture, un-decomposed organic matter on the soil surface, low soil pH and high temperature (25 to 30°C) at the time of initial crop stage due to rice-chickpea or soybean-chickpea cropping pattern. Soybean and rice plants also susceptible host of the fungus and pathogen having the ability to produce large number of sclerotia which is persist in the soil for several years. Hence management of collar rot of chickpea caused by *Sclerotium rolfsii* is very difficult to achieve chemically alone. Besides, this control of collar rot of chickpea is not feasible because much higher cost required for controlling the disease. However, the use of biocontrol agents like *Trichoderma harzianum* which has ability to antagonize fungal plant pathogens but it is working very slowly. Keeping these in view an experiment was conducted to see the efficacy of *Trichoderma harzianum* alone and its integration with fungicides against collar rot caused by *Sclerotium rolfsii* in chickpea.

Materials and Methods

An experiments was layout on efficacy of *Trichoderma harzianum* alone and integration of fungicides collar rot disease of chickpea caused by *Sclerotium rolfsii* in Chhattisgarh region under Split Plot Design (SPD) with two main plots as method of seed treatment *viz*., seed dressing, seed soaking and nine sub-plot as Treatments viz. T_1 = Hexaconazole @ 3g Kg^{-1} seed, T_2 = Carboxin+ thiram @ 3g Kg^{-1} seed, T_3 = *T. harzianum* @ 10g Kg^{-1} seed, T_4 = Hexaconazole @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg-1 seed, T_5 = Carboxin+ thiram @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed, T_6 = *T. harzianum* @ 10g Kg^{-1} seed with Jaggary @ 10g Kg^{-1} seed, T_7 = Hexaconazole @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed with Jaggary @ 10g Kg^{-1} seed, T_8 = Carboxin+ thiram @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed with Jaggary @ 10g Kg^{-1} seed and T_9 = Control.

Table-1 Effect of combination of *Trichoderma harzianum* and fungicides and method of seed treatment on germination in *Sclerotium rolfsii* sick plot

Treatment	Germination (%)					
	2013-14			2014-15		
	Dressing	Soaking	Mean	Dressing	Soaking	Mean
T_1 = Hexaconazole @ 3g Kg^{-1} seed	70.25	74.59	72.42	73.16	80.29	76.73
T_2 = Carboxin+ thiram @ 3g Kg^{-1} seed	76.70	81.88	79.29	81.00	85.58	83.29
T_3 = *T. harzianum* @ 10g Kg^{-1} seed	72.71	76.86	74.79	74.24	83.86	79.05
T_4 = Hexaconazole @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} see	79.41	84.83	82.12	82.38	85.83	84.11
T_5 = Carboxin+ thiram @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed	81.44	86.04	83.74	84.52	86.04	85.28
T_6 = *T. harzianum* @ 10g Kg^{-1} seed with Jaggary @ 10g Kg^{-1} seed	73.52	79.85	76.69	76.36	81.85	79.11
T_7 = Hexaconazole @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed with Jaggary @ 10g Kg^{-1} seed	82.76	89.04	85.90	86.48	91.04	88.76
T_8 = Carboxin+ thiram @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed with Jaggary @ 10g Kg^{-1} seed	85.98	92.25	89.12	88.40	93.25	90.83
T_9 = Control	71.70	75.37	73.53	73.55	80.37	76.96
Mean	77.16	82.30		80.01	85.35	
	C.V. (%)	SEm±	C.D. at 5%	C.V. (%)	SEm±	C.D. at 5%
Main Plot	12.15	1.67	4.81	11.67	1.69	4.87
Sub-Plot		0.92	2.67		0.79	2.80
Main Plot x Sub-Plot		2.32	NS		2.38	NS

Table-2 Effect of combination of *Trichoderma harzianum* and fungicides on collar rot of chickpea caused by *Sclerotium rolfsii*

Treatment	Mortality (%)					
	2013-14			2014-15		
	Dressing	Soaking	mean	Dressing	Soaking	Mean
T_1 = Hexaconazole @ 3g Kg^{-1} seed	9.73 (18.16)	9.07 (17.52)	9.40 (17.84)	10.00 (18.43)	10.70 (19.08)	10.35 (18.75)
T_2 = Carboxin+ thiram @ 3g Kg^{-1} seed	16.57 (24.00)	14.63 (22.47)	15.60 (23.23)	19.06 (25.87)	17.26 (24.53)	18.16 (25.02)
T_3 = *T. harzianum* @ 10g Kg^{-1} seed	28.91 (32.51)	18.79 (25.67)	23.85 (29.09)	33.25 (35.20)	22.17 (28.07)	27.71 (31.64)
T_4 = Hexaconazole @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed	8.30 (16.73)	9.98 (18.40)	9.14 (17.57)	11.19 (19.53)	11.78 (20.06)	11.49 (19.80)
T_5 = Carboxin+ thiram @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed	14.35 (22.25)	13.64 (21.66)	14.00 (21.95)	16.50 (23.96)	16.10 (23.65)	16.30 (23.80)
T_6 = *T. harzianum* @ 10g Kg^{-1} seed with Jaggary @ 10g Kg^{-1} seed	25.34 (30.21)	23.96 (29.29)	24.65 (29.75)	29.14 (32.65)	28.27 (32.10)	28.71 (32.38)
T_7 = Hexaconazole @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed with Jaggary @ 10g Kg^{-1} seed	8.09 (16.51)	7.17 (15.52)	7.63 (16.01)	9.30 (17.75)	8.46 (16.90)	8.88 (17.32)
T_8 = Carboxin+ thiram @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed with Jaggary @ 10g Kg^{-1} seed	13.50 (21.55)	10.83 (19.20)	12.17 (20.37)	15.53 (23.20)	12.78 (20.93)	14.16 (22.07)
T_9 = Control	40.16 (39.30)	27.26 (31.45)	33.71 (35.38)	46.18 (42.79)	32.17 (34.54)	39.18 (38.66)
Mean	18.33 (24.58)	15.04 (22.35)		21.13 (26.60)	17.74 (24.43)	
	CV (%)	SEm±	C.D. at 5%	CV (%)	SEm±	C.D. at 5%
Main Plot	13.35	0.36	1.05	12.65	0.29	0.85
Sub-Plot		0.17	0.49		0.14	0.40
Main Plot x Sub-Plot		0.51	1.48		0.41	1.20

All the treatment combinations were randomly replicated thrice. Different combinations of fungicides and *Trichoderma harzianum* were on seed as dressing or soaking as per the treatment details. Chickpea seeds were treated with fungicides/ *Trichoderma harzianum* alone and combinations of fungicides and *Trichoderma harzianum* as treatment details mentioned above. In case of seed dressing, first seeds were treated with fungicide followed *Trichoderma harzianum*. In case of seed soaking method, first seeds were soaked with fungicides for 10 minutes and dried followed by seed treatment with Trichoderma suspension @ 106cfu. Treated deeds of variety JG-226 were sown in the plot size of 1.2 x 1 m with row to row distance 30 cm and plant to plant 10 cm. Sick plots were prepared by incorporating of sclerotia @ 120g/plot *Sclerotium rolfsii* culture containing 6-7 sclerotia g^{-1} of culture. Germination of seeds was recorded from each treatment after 10 days of sowing. Observation on mortality was recorded at fortnightly interval in which total and rotted plants were recorded from each experimental plot. Yield data was also recorded from the all experimental plot. The per cent mortality was calculated with following formula:

$$\text{Percent mortality} = \frac{\text{Number of plants died due to disease (Plot} - 1)}{\text{Total number of plants (Plot} - 1)} \times 100$$

Results and discussion

Data pertaining to effect of *Trichoderma harzianum* and fungicides and their combinations on seed germination, mortality and grain yield have been presented here:

Seed germination

Experimental data on seed germination have been presented in table 1 indicated that the seed germination was significant influenced by the treatments.

Highest seed germination of 89.12 and 90.93 percent was recorded in treatment T_8 = Carboxin+ thiram @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed with Jaggary @ 10g Kg^{-1} seed followed by T_7 = Hexaconazole @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed with Jaggary @ 10g Kg^{-1} seed (85.90 and 88.76%) during 2013-14 and 2014-15, respectively. However, in control plot it was found 73.53 and 76.96 percent during 2013-14 and 2014-15, respectively. In case of methods of application, seed soaking showed higher seed germination (82.30 and 85.35%) as compare to seed dressing which showed 77.16 and 80.01 percent seed germination during 2013-14 and 2014-15, respectively. Interaction was found non-significant.

Mortality

Data on mortality of chickpea plant in different treatments have been presented table 2 indicated that the minimum mortality (7.63 and 8.88%) was recorded in treatment T_7 = Hexaconazole @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed with Jaggary @ 10g Kg^{-1} seed which was significantly lower over rest of the treatments. In case of method of application most superior method was found seed soaking which showed least mortality 15.04 and 17.74 percent during 2013-14 and 2014-15, respectively. Interaction between treatment and method of application was found significant. Minimum mortality of chickpea plant due to collar rot disease recorded was 7.17 and 8.46 percent in treatment T_7 = Hexaconazole @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed with Jaggary @ 10g Kg^{-1} seed applied as seed soaking during 2013-14 and 2014-15, respectively.

Grain yield

Grain yield $plant^{-1}$ obtained in all the treatments have been presented in table 3 reveal that the highest grain yield (18.71 Kg and 17.26 Kg $plant^{-1}$) was obtained in treatment T_7 = Hexaconazole @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed with Jaggary @ 10g Kg^{-1} seed during 2013-14 and 2014-15, respectively. It was at par with treatment T_8 = Carboxin+ thiram @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed with Jaggary @ 10g Kg^{-1} seed (17.88 Kg $plant^{-1}$), T_4 = Hexaconazole @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed (17.85 Kg $plant^{-1}$) during 2013-14 and significantly superior over rest of the treatment. However, during 2014-15 treatment T_7 = Hexaconazole @ 3g Kg^{-1} seed+ *T. harzianum* @ 10g Kg^{-1} seed with Jaggary @ 10g Kg^{-1} seed was found significantly superior over all the treatments. Seed soaking method of application was found better as compare to seed dressing during both the year. Interaction between treatment and method of application was found non-significant. The results clearly indicated that the *Trichoderma harzianum* alone and combination with fungicides reduced the mortality due to *S. rolfsii* in chickpea plants and promote the plant growth and yield. Several reports show that seed treatment with *T. harzianum* reduces the population of *S. rolfsii*. The investigation of biological control agents proved the ability to manage collar rot disease of chickpea. Trichoderma and fungicides have been widely used as a seed treatment in managing soil borne pathogens. Thus, the application of *Trichoderma harzianum* not only control the disease but also enhance plant growth, yield and ecologically safe and can be regarded as healthy approach for controlling collar rot (*S. rolfsii*) of chickpea. Similar finding was reported by Singh, et al. (2017) [8]. They reported that the most effective treatment was *Trichoderma harzianum* @ 8q/ha^{-1} (Soil) + Hexaconazole @ 3ml/kg^{-1} seed with minimum mortality (4.30 and 2.25%) which was at par with treatment *Pseudomonas fluorescens* @ 8q/ha^{-1} (Soil) + Hexaconazole @ 3ml/kg^{-1} seed (5.80 and 2.59%) and *Trichoderma harzianum* @ 8q/ha^{-1} (Soil)+Tubeconazole @ 3ml/kg^{-1} seed (6.15 and 4.09%) whereas maximum mortality 15.70 and 12.35%) was recorded in control plot. Maximum no. of pods per plant (41.30 and 49.75) was recorded in treatment T_7 = *Trichoderma harzianum* @ 8q/ha^{-1} (Soil) + Hexaconazole @ 3ml/kg^{-1} seed which was at par with T_8 = *Pseudomonas fluorescens* @ 8q/ ha^{-1} (Soil) + Hexaconazole @ 3ml/kg^{-1} (38.7 and 45.95) and significantly superior over rest of the treatment. In case of grain yield highest grain yield was increased in treatment T_7 = *Trichoderma harzianum* @ 8q/ha^{-1} (Soil) + Hexaconazole @ 3ml/kg^{-1} seed (44.85%) followed by T_8 = *Pseudomonas fluorescens* @ 8q/ha^{-1} (Soil) + Hexaconazole @ 3ml/kg^{-1} (43.61%) and T_{10} = *Pseudomonas fluorescens* @ 8q/ha^{-1} (Soil) + Tubeconazole @ 3ml/kg^{-1} seed (29.63%). Our results were partially supported with finding of several [9-11]. Veena and Reddy, (2016) [12] revealed that the seed treatment with Copper Oxychloride + soil application of potential fungal (Trichoderma isolate-7) and bacterial bio-control agent was found to be superior as it recorded the highest germination percentage (100 %), highest initial (10.00) and final population of chickpea (9.66), least PDI (16.00 %), maximum plant height (25.61 cm), root length (13.40 cm) and maximum shoot (0.49 g) and root dry weights (0.11 g). The population dynamics of both antagonists and pathogen were estimated at two different intervals initially at 7 DAS and then on 45 DAS in pot culture experiment.

Application of research: It is concluded that the research finding of our work directly applicable at farmers level to minimize significantly reduction in mortality of chickpea plant caused by *S. rolfsii*.

Abbreviations: DAS = Days after sowing, cm= centimetre,
Kg = kilogram, g = gram

Research Category: Biological control, integrated disease management

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