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Management of Sclerotinia Rot of Chickpea (*Cicer arietinum* L.) Incited by *Sclerotinia sclerotiorum* (Lib.) De Bary

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ABSTRACT

Background: *Sclerotinia sclerotiorum* (Lib.) de Barry is a soil-borne plant pathogen, capable of infecting more than 500 host plant species worldwide and plays a crucial role in reducing the yield of economically important crops.

Methods: A field experiment was conducted to manage Sclerotinia rot of chickpea using bioagents, fungicides, soil amendments and plant extract for two crop seasons using variety GNG-1581 in field under artificial inoculation conditions. Observations on Sclerotinia rot incidence were recorded periodically. The grain yield was also recorded at harvest.

Result: A combination of seed (5+5 g/kg seeds) as well as soil (5+5 kg/ha) application of *T. harzianum* + *P. fluorescens* and foliar spray of carbendazim 12% + mancozeb 63% @ 0.2 per cent was found to be most effective reducing Sclerotinia rot (84.59%) and in enhancing grain yield (87.50%).

Key words: Bioagents, Chickpea, Sclerotinia rot, *Sclerotinia sclerotiorum*.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is an important grain legume in the Indian subcontinent, West Asia and Africa and Central and South America. It is known by other names like gram, spanish pea, chestnut bean (English) and Chana (Hindi) *etc*. On global basis, chickpea is the third most important grain legume after common bean and pea (Anwar *et al.,* 2009). Asia covers 89.7 per cent in Oceania, 2.9 percent in America and 0.4 per cent in Europe (Gaur *et al.,* 2010).

India ranks first in terms of chickpea production and consumption in the world. About 65 per cent of the global area with 68 per cent of global production is contributed by India (Reddy and Mishra, 2010). The major chickpea producing countries are India, Pakistan, Ethiopia, Burma, Turkey, Mexico and Australia.

It accounts for 70 per cent cultivated *Rabi* pulses in India. The major chickpea growing states in India are Madhya Pradesh (41%) followed by Maharashtra (16%), Rajasthan (15%), Karnataka (6%), Andhra Pradesh (5%), Uttar Pradesh (5%) and other remaining states and UTs of India (12%). The total area under chickpea cultivation in India is about 10.56 million ha with annual production of 11.23 million tonnes. The average productivity of chickpea is 1063 kg/ha. (Anonymous 2017-18a).

In Rajasthan, the major chickpea growing districts are Bikaner, Churu, Jhunjhunu, Hanumangarh, Sri Ganganagar, Jaipur, Sikar and Ajmer. The total area and production of chickpea in Rajasthan is 1.57 million ha and 1.67 million tonnes, respectively, having productivity of 1062 kg/ha (Anonymous 2017-18b).

Chickpea is a protein rich supplement to all cereal based diets, especially for vegetarians. Its protein is rich in lysine and has low sulphur containing amino acid. Hence, it is widely appreciated as healthy food. On an average, chickpea contains protein (12.4 to 31.5%), carbohydrate (48.2 to 67.6%) and fat (6%) (Anwar *et al*., 2009). The mineral component is high in chickpea as it contains phosphorus (340 mg/100 g), calcium (190 mg/100 g), iron (7 mg/100 g), zinc (3 mg/100 g) and vitamin B in considerable amounts (Anonymous 2008).

Stem rot was initially observed at ARS Ummedganj, Kota in the year 1993-94 and thereafter, it has been appearing continuously in mild to severe form. The pathogen infects collar region, stem and foliage leading to mortality of the plants. The fungus characterized by the formation of hard blackish sclerotia, which on germination produce cup shaped brown colored apothecia.

Sclerotinia sclerotiorum (Lib.) de Bary is a necrotrophic pathogen with cosmopolitan distribution and wide host range (Purdy, 1979) and belongs to the family Sclerotiniaceae (Whetzel, 1945) class Ascomycetes. It produces sclerotia and apothecia but lacks conidial stage.

The disease has been reported from different parts of India and causing considerable losses. Its occurrence was first reported from Himachal Pradesh with considerable yield

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losses (Grewal and Pal, 1986). The extent of damage ranged from 21.3% to 46.7% at pod bearing stage of the crop (Sharma, 1995). In Jammu and Kashmir, the disease incidence varied from 18.7% (Udhampur) to 32.2% (Jammu). (Vaid *et al.,* 2005).

Affected plants first wilted and rapidly die, often without turning yellow. Later, as the plant dries out, the leaves turn straw color. On the surface of the root, just below ground level, small black fungal bodies called sclerotia, which are irregular in size and shape, can sometimes be seen mingled with white cottony fungal mycelium.

A number of fungicides were evaluated against the pathogen and some of them were found effective in reducing the losses caused by the pathogen in canola crop (Bradley *et al.,* 2006). However, use of chemicals alone is not economical and eco-friendly for such disease. Since the pathogen is soil borne and perpetuates through its sclerotia, hence its management by the use of chemicals alone becomes impracticable. Various fungal bio-control agents and soil amendments have been evaluated by various workers against *S. sclerotiorum* (Sharma *et al.* 1999).

MATERIALS AND METHODS

A field experiment was conducted to manage chickpea Sclerotinia rot using bioagents, fungicides, soil amendments and plant extract for two consecutive seasons 2016-17 and 2017-18 using variety GNG-1581.

Through bioagents

Talc based formulations of two bioagents *viz., Trichoderma harzianum* (Th-BKN) and *Pseudomonas fluorescens* (PF-BKN) were used individually @ 10 g/kg seed as well as combinations of both bioagents (5+5) g/kg for seed treatment, respectively. Similarly, for soil application these were used individually @ 10 kg/ha and in combination of both bioagents @ (5+5) kg/ha with farm yard manure (FYM) @ 250 kg/ha uniformly applied in field before sowing.

Through fungicides

Three fungicides *viz.,* tebuconazole 2 DS (0.1%) carbendazim 12% + mancozeb 63% (0.2%), tebuconazole 50% + trifloxystrobin 25% (75 WG) (0.1%) were used for seed treatment and foliar spray.

Through soil amendments

Two soil amendments *viz.,* neem and castor cake were used @ 500 kg/ha as soil application. Soil amendments were applied five days before sowing of seed.

Through plant extract

Garlic extract was prepared with the help of mortar and pestle by crushing dried plant parts and adding sterilized distilled water (1:1 W/V). The extract was filtered through double layer of muslin cloth. The appropriate amount of garlic extract was mixed in sterilized distilled water (W/V) to make the desired concentration of 10 % by dissolving 10 g of garlic clove extract in 100 ml of sterilized water, respectively.

Total twenty one treatments including control were tested in Randomized Block Design having plot size 4×3 m. Each treatment was replicated two times. The trial was conducted under artificial soil infestation conditions. For this purpose, sand maize meal inocula of *S. sclerotiorum* was applied at 50 g per plot (4×3 m) thoroughly on top surface soil using a hand rack. Standard agronomic practices recommended for cultivation of chickpea crop in this region were followed. In case of control, the untreated seeds were sown in unammended plots. Observations on Sclerotinia rot incidence were recorded periodically. The grain yield was also recorded at harvest.

Details of treatments used for managing Sclerotinia rot

T_1: Seed treatment (ST) with *T. harzianum* @ 10 g/kg + Soil application (SA) with *T. harzianum* @ 10 kg/ha
T_2: ST with *P. fluorescencs* @ 10 g/kg + Soil application (SA) with *P. fluorescencs* @ 10 kg/ha
T_3: ST with *T. harzianum* @ 5 g/kg + ST with *P. fluorescencs* @ 5 g/kg + SA with *T. harzianum* @ 5 kg/ha + SA with *P. fluorescencs* @ 5 kg/ha
T_4: T_1 + SA of castor cake @ 500 kg/ha.
T_5: T_1 + SA of neem cake @ 500 kg/ha.
T_6: T_2 + SA of castor cake @ 500 kg/ha.
T_7: T_2 + SA of neem cake @ 500 kg/ha.
T_8: T_3 + SA of castor cake @ 500 kg/ha.
T_9: T_3 + SA of neem cake @ 500 kg/ha.
T_{10}: T_4 + Foliar spray (FS) of garlic extract @ 10%.
T_{11}: T_5 + FS of garlic extract @ 10%.
T_{12}: T_6 + FS of garlic extract @ 10%.
T_{13}: T_7 + FS of garlic extract @ 10%.
T_{14}: T_8 + FS of garlic extract @ 10%.
T_{15}: T_9 + FS of garlic extract @ 10%.
T_{16}: ST with carbendazim 12% + mancozeb 63% @ 0.2% + FS with carbendazim 12% + mancozeb 63% @ 0.2%.
T_{17}: ST with tubuconazole 2 DS @ 1.5 g/kg + FS with tubuconazole 50% + trifloxystrobin 25% @ 0.1%.
T_{18}: T_1 + FS with carbendazim 12% + mancozeb 63% @ 0.2%.
T_{19}: T_2 + FS with carbendazim 12% + mancozeb 63% @ 0.2%.
T_{20}: T_3 + FS with carbendazim 12% + mancozeb 63% @ 0.2%.
T_{21}: Control.

RESULTS AND DISCUSSION

In this study, five treatment combinations were tested under field condition *viz.,*

(I) Seed treatment @ 10 g/kg seed + Soil application of bioagents @ 10 kg/ha (*T. harzianum* and *P. fluorescencs*) individually as well as combination of both the bioagents.

(II) Seed treatment + Soil application of *T. harzianum* and *P. fluorescencs* individually as well as combination of both the bioagents + Soil application of neem cake and castor cake @ 500 kg/ha.

(III) Seed treatment + Soil application of *T. harzianum* + *P. fluorescencs* individually as well as combination of both the bioagent + Soil application of neem cake and castor cake along with foliar spray of garlic extract @ 10%.

(IV) Seed treatment with carbendazim 12% + mancozeb 63% @ 0.2% + Foliar spray (FS) with carbendazim 12% + mancozeb 63% @ 0.2% and Seed treatment with tubuconazole 2 DS @ 1.5 g/kg + Foliar spray (FS) of tubuconazole 50% + trifloxystrobin 25% @ 0.1%.

(V) Seed treatment + Soil application of *T. harzianum* and *P. fluorescencs* individually as well as combination of both the bioagent + Foliar spray of carbendazim 12% + mancozeb 63% @ 0.2%

Treatment combination, with *T. harzianum* + *P. fluorescencs* @ 5+5 g/kg seed + with *T. harzianum* + *P. fluorescencs* @ 5+5 kg/ha found superior with 27.75% disease incidence and 12.05 kg/ha yield as compared to the treatments where bioagents were applied alone.

Treatments combination, ST with *T. harzianum* + *P. fluorescencs* @ 5+5 g/kg seed + with *T. harzianum* + *P. fluorescencs* @ 5+5 kg/ha + SA of neem cake @ 500 kg/ha was found superior having the disease incidence of 19.90% and 14.30 kg/ha yield as compared to other treatment combination where bioagents were applied individually along with neem cake and castor cake or combination of both the bioagents along with castor cake.

Treatments combination, ST with *T. harzianum* + *P. fluorescencs* @ 5+5 g/kg seed + SA with *T. harzianum* + *P. fluorescencs* @ 5+5 kg/ha + SA of neem cake @ 500 kg/ha + FS of garlic extract @ 10% was found superior with minimum disease incidence of 13.10% and higher grain yield of 16.85 kg/ha as compared to others treatments where bioagents were applied individually with neem cake and castor cake or combination of both the bioagents with castor cake along with foliar spray of garlic extract @ 10%.

In these three types of combinations, bioagents and soil amendments were used to produce organic product these can minimize the disease by organic products.

Treatments combination where only fungicides were used, as ST with tubuconazole 2 DS @ 1.5 g/kg seed + FS of tubuconazole 50% + trifloxystrobin 25% @ 0.1% was found superior with the disease incidence of 8.95% and grain yield of 18.50 kg/ha.

Treatment combination, where bioagents and fungicidal treatments used and found that seed treatment with *T. harzianum* + *P. fluorescencs* @ 5+5 g/kg + SA of *T. harzianum* + *P. fluorescencs* @ 5+5 kg/ha + FS of carbendazim 12% + mancozeb 63% @ 0.2% was found superior with minimum disease incidence of 6.10% and highest grain yield of 19.50 q/ha.

The chickpea grain yield was significantly enhanced when bioagents used as seed treatment and soil application along with foliar spray of fungicides. The highest grain yield of 19.50 q/ha was recorded in seed treatment with *T. harzianum* plus *P. fluorescencs* @ 5+5 g/kg seed + soil application with *T. harzianum* plus *P. fluorescencs* @ 5+5 kg/ha along with foliar spray of carbendazim 12% + mancozeb 63% @ 0.2% followed by the treatment comprising seed treatment with *T. harzianum* @ 10 g/kg seed + SA of *T. harzianum* @ 10 kg/ha along with foliar spray of carbendazim 12% + mancozeb 63% with 18.95 q/ha, both the treatments were statistically at par as compared to control where 10.40 q/ha grain yield was recorded (Table 1).

The present finding on the management of chickpea Sclerotinia rot is in conformity with findings of those reported by Pandey *et al.* (2011) who had reported that *Trichoderma harzianum* plus vermi-compost was the most effective in reducing the disease incidence in chickpea. Meena *et al.* (2014) evaluated the efficacy of different treatments including talc based formulations of four *Trichoderma harzianum* isolates used as seed treatment @ 5 g/kg seed and soil application with farm yard manure @ 2 g/kg. The highest reduction of the Sclerotinia rot (69.0%) was achieved by *T. harzianum* isolates GR over control. Patel *et al.* (2011) tested the efficacy of *P. fluorescens* isolates against Sclerotinia rot of chickpea both *in vitro* and *in vivo* condition and reported that seed treatment with strains of *Pseudomonas fluorescens* significantly reduced the disease incidence of stem rot in all treatments in comparison to uninoculated control. Kumawat *et al.* (2018) tested some fungicides *viz.,* carbendazim and carbendazim 12% + mancozeb 63% against *S. sclerotiorum* under field condition as seed application, foliar application and seed cum foliar application. They reported that carbendazim was found most effective in reducing the disease intensity followed by carbendazim 12% + mancozeb 63% WP. Bairwa *et al.* (2015) tested different fungicides *viz.,* metalaxyl 8% + mancozeb 64% @ 0.2% and ST with carbendazim 50 WP @ 2 g/kg seed + 2 FS of carbendazim 12% + mancozeb 63% @ 0.2% and concluded that seed treatment with carbendazim 50 WP at 2 g/kg seed followed by two sprays of carbendazim 12% + mancozeb 63% mixture (0.2%) and removal of three lower leaves followed by foliar spray of metalaxyl 8% + mancozeb 64% WP (0.2%) minimizes the major diseases and maximized the yield of mustard.

The chickpea grain yield was significantly enhanced when bioagents used as seed treatment and soil application along with foliar spray of fungicides. The highest grain yield of 19.50 q/ha was recorded in seed treatment with *T. harzianum* plus *P. fluorescencs* @ 5+5 g/kg seed + Soil application with *T. harzianum* plus *P. fluorescencs* @ 5+5 kg/ha alongwith foliar spray (FS) of carbendazim 12% + mancozeb 63% @ 0.2% followed by the treatment comprising seed treatment with *T. harzianum* @ 10 g/kg seed + SA of *T. harzianum* @ 10 kg/ha alongwith foliar spray of carbendazim 12% + mancozeb 63% with 18.95 q/ha, both the treatments were statistically at par as compare to control where 10.40 q/ha grain yield was recorded.

Similarly, combination of chemical as well as biological methods for obtaining the optimum yield with minimum losses have also reported by several workers. Meena *et al.* (2011) observed that *T. harzianum* and *P. fluorescens* did not differ significantly in controlling stem rot in mustard. Similar results were observed by treating the seeds with garlic bulb extract, *T. harzianum* and spraying of *P. fluorescens.* Sharma *et al.* (2017) evaluated the efficacy of carbendazim as seed treatment and foliar spray against *S. sclerotiorum*

Table 1: Efficacy of bio-agents, organic amendments and fungicides in controlling Sclerotinia rot of chickpea.

T. no.	Treatment	Disease incidence (%)**			Disease control (%)	Seed yield (q/ha)**		Pooled	Increase in yield over control
		2016-17	2017-18	Pooled		2016-17	2017-18		
T_1	ST with *T. harzianum* @ 10 g/kg + Soil application (SA) with *T. harzianum* @ 10 kg/ha	26.65 (31.08)*	31.60 (34.20)*	29.13 (32.64)*	26.41	11.20	12.30	11.75	12.98
T_2	ST with *P. fluorescence* @ 10 g/kg + SA with *P. fluorescence* @ 10 kg/ha	27.30 (31.42)	33.30 (35.23)	30.30 (33.32)	23.45	11.00	11.70	11.35	9.14
T_3	ST with *T. harzianum* @ 5g/kg + ST with *P. fluorescence* @ 5 g/kg + SA with *T. harzianum* @ 5 kg/ha + SA with *P. fluorescene* @ 5 kg/ha	25.50 (30.26)	30.00 (33.21)	27.75 (31.73)	29.89	11.50	12.60	12.05	15.87
T_4	T_1 + SA of Castor cake @ 500 kg/ha	20.50 (26.91)	25.65 (30.34)	23.08 (28.63)	41.70	12.50	14.00	13.25	27.40
T_5	T_1 + SA of Neem cake @ 500 kg/ha	19.20 (25.98)	24.50 (29.66)	21.85 (27.82)	44.79	12.90	13.80	13.35	28.36
T_6	T_2 + SA of Castor cake @ 500 kg/ha	24.00 (29.33)	28.80 (32.45)	26.40 (30.89)	33.30	11.80	14.50	13.15	26.44
T_7	T_2 + SA of Neem cake @ 500 kg/ha	21.70 (27.76)	27.75 (31.79)	24.73 (29.77)	37.53	12.00	13.30	12.65	21.63
T_8	T_3 + SA of Castor cake @ 500 kg/ha	18.50 (25.47)	23.10 (28.72)	20.80 (27.09)	47.45	13.30	14.40	13.85	33.17
T_9	T_3 + SA of Neem cake @ 500 kg/ha	17.80 (24.95)	22.00 (27.97)	19.90 (26.46)	49.72	13.90	14.70	14.30	37.50
T_{10}	T_4 + FS of Garlic extract @ 10%	15.00 (22.78)	19.00 (25.83)	17.00 (24.31)	57.05	15.20	16.60	15.90	52.88
T_{11}	T_5 + FS of Garlic extract @ 10%	14.20 (22.13)	17.50 (24.73)	15.85 (23.43)	59.95	15.70	17.20	16.45	58.17
T_{12}	T_6 + FS of Garlic extract @ 10%	17.00 (24.35)	21.70 (27.76)	19.35 (26.05)	51.11	14.30	15.80	15.05	44.71
T_{13}	T_7 + FS of Garlic extract @ 10%	16.70 (24.12)	20.50 (26.71)	18.60 (25.52)	53.01	14.80	16.10	15.45	48.55
T_{14}	T_8 + FS of Garlic extract @ 10%	13.10 (21.21)	16.00 (23.57)	14.55 (22.39)	63.24	17.40	15.40	16.40	57.69
T_{15}	T_9 + FS of Garlic extract @ 10%	12.00 (20.26)	14.20 (22.13)	13.10 (21.20)	66.90	16.10	17.60	16.85	62.03
T_{16}	ST with Carbendazim 12% + Mancozeb 63% @ 0.2% FS with Carbendazim 12% + Mancozeb 63% @ 0.2%	9.80 (18.24)	11.00 (19.37)	10.40 (18.80)	73.72	16.60	18.20	17.40	67.30
T_{17}	ST with Tubuconazole 2 DS @ 1.5 g/L + FS with Tubuconazole 50% + Trifloxystrobin 25% @ 0.1%	8.15 (16.59)	9.80 (18.24)	8.98 (17.41)	77.32	18.00	19.00	18.50	77.88
T_{18}	T_1 + FS with Carbendazim 12% + Mancozeb 63% @ 0.2 %	6.75 (15.06)	7.20 (15.56)	6.98 (15.31)	82.38	18.30	19.60	18.95	82.21
T_{19}	T_2 + FS with Carbendazim 12%+ Mancozeb 63% @ 0.2%	11.15 (19.50)	12.50 (20.70)	11.83 (20.10)	70.12	17.00	15.00	16.00	53.84
T_{20}	T_3 + FS with Carbendazim 12% + Mancozeb 63% @ 0.2%	5.50 (13.56)	6.70 (15.00)	6.10 (14.28)	84.59	19.00	20.00	19.50	87.50
T_{21}	Control	38.15 (38.10)	41.00 (39.79)	39.58 (38.95)	0.00	10.00	10.80	10.40	0.00
	S.Em (±)	0.87	0.80	0.51		1.05	1.21	0.69	
	C.D (P=0.05)	2.49	2.28	1.44		3.00	3.48	1.96	
	C.V (%)	6.23	6.35	6.08		6.50	6.79	6.30	

*Figures in parentheses are angular transformed values; **Mean of three replications; ST- Seed treatment; SA- Soil application; FS- Foliar spray.

and recorded maximum reduction in infection (88%) with increased pooled mean grain yield (2439 kg/ha). Senjaliya *et al.* (2016) tested the efficacy of the bioagents, fungicides and soil amenmends and found that castor cake as soil organic amendment significantly reduce the disease with minimum disease incidence of 2.6% and the pod yield of 1773.67 kg/ha.

CONCLUSION

The combined effect of seed (5+5 g/kg seeds) as well as soil (5+5 kg/ha) application of *T. harzianum* + *P. fiuorescens* and foliar spray of carbendazim 12% + mancozeb 63% (0.2%) was found most effective in reducing Sclerotinia rot (84.59%) and in enhancing grain yield (87.50%).

Conflict of interest: None.

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