RESEARCH ARTICLE

MANAGEMENT OF *MACROPHOMINA PHASEOLINA* INDUCED CHARCOAL ROT OF COWPEA THROUGH BIOAGENTS AND FUNGICIDES UNDER FIELD CONDITIONS

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Abstract: The charcoal rot of cowpea (*Vigna unguiculata* (L.) Walp) is caused by *Macrophominaphaseolina.* It affects many crops worldwide causing devastatingly high yield losses. No single control measures are found to be much effective owing to its soil-borne nature. In order to manage the disease, a field experiment was conducted to determine the effectiveness of biocontrol agents*viz.*, *Trichodermaharzianum* and *Pseudomonas fluorescens* and fungicides *viz.*, tebuconazole 2DS, tebuconazole 50% + trifloxystrobin 25% WG, carbendazim 12% + mancozeb 63% WP and captan 70%WP were used alone as well as in combinations. When fungicides were applied as seed treatment and soil drench together, tebuconazole 50%+ trifloxystrobin 25% WG was proved to be most effective against charcoal rot by decreasing disease incidence and increasing grain yield followed by carbendazim 12% + mancozeb 63% WP.Seed treatment and foliar spray when applied alone, were found to be effective against *M. phaseolina* but the results revealed that they were less effective than combination treatment of fungicides. Bio-agents minimized the incidence of disease but to a lower extent than fungicides. A relatively more disease control was observed by *T. harzianum* followed by *P. fluorescens.*

Keywords: Charcoal rot, *Macrophominaphaseolina*,*Pseudomonas fluorescens*, Soil-borne, *Trichoderma harzianum*

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) also known as 'vegetable meat'due to its high nutritional value and early maturity is an important legume crop of *kharif* season grown extensively in arid, semi-arid, tropical and sub-tropical regions throughtout the world (PainoD'urzo*et al.,* 1990). Cowpea is prone to several diseases, among them *Macrophominaphaseolina*induced charcoal rot of cowpea is emerging as a severe problem leading to high yield losses (Mucher*oet al*., 2011; Kaur *et al*., 2012; Bouka*ret al*., 2019). *M. phaseolina*is an important soil-inhabiting fungus. Its prevalence could be enhanced by different ecological and physiological factors likehigh temperature, low moisture content and heat (Dhingra and Sinclair, 1978).The disease is mostly prevalent during hot temperature range of 30 to 35°C and low soil moisture regimes (Pande and Sharma, 2010). The characteristic symptom of charcoal rot was yellowing of leaves followed by dropping of leaves within two of three days. On the collar region, dark lesions were seen. When the plants were pulled out from the soil, the basal stem and main roots showed rotting symptoms.Soil-borne diseases can effectively be managed by resistant varieties to a great extent but due to their inability to maintain resistance for long duration owing to the constant variations in nature of pathogen and various other edaphic factors, they are preferred less for the management of soil-borne disease. As for chemical control, they are not fit to be used on long term basis but since they give immediate results, they are being exploited since now. Inhibition and control of plant pathogens by biological methods is more economical and advantageous over chemicals (Cothran*et al*., 2013) but they give slow results. So an integrated approach is the need of hour.

MATERIALS AND METHODS

A field trial was carried out for management of charcoal rot of cowpea (RC-19) using efficient bioagents and fungicides in *kharif* 2018. Talc based inoculations of one fungal & one bacterial bioagent viz., *T. harzianum* and *P. fluorescens* and fungicides*viz.*, tebuconazole 2DS, tebuconazole 50% + trifloxystrobin 25% WG, carbendazim 12% + mancozeb 63% WP, captan 70%WP were used alone as well as in combinations. Seed treatment with fungicides tebuconazole 2DS @1.5gkg^{-1} seed, carbendazim 12% + mancozeb 63% WP as well as captan 70%WP@ 2gkg^{-1}, foliar spray with tebuconazole 50% + trifloxystrobin 25% WG@ 1.5gL^{-1}, carbendazim 12% + mancozeb 63% WP as well as captan 70% WP $_{@}$ 2gL^{-1} was followed. Seed treatment and soil drench of tebuconazole 50% + trifloxystrobin 25% WG@ 1.5gkg^{-1} and@ 1.5gL^{-1} waterrespectively, carbendazim 12% + mancozeb 63% WP and captan 70% WP @ 2gkg^{-1} and soil drench@ 2gL^{-1} waterrespectivelywas followed. A combined application as seed treatment + soil application of two bioagents *viz.*, *T. harzianum* and *P. fluorescens* was used against charcoal rot of

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cowpea. 10 kg ha^{-1}talc-based formulation of bioagents prepared in the laboratory was thoroughly mixed with FYM for soil application. 2gkg^{-1}talc-based formulation of bio-agents seed were used as seed treatment.

Treatments

Treatment	Dose
T_{1-} tebuconazole 2DS	ST @ 1.5 g/kg seed
T_2- carbendazim 12% + mancozeb 63% WP	ST @ 2g /kg seed
T_{3-} captan70%WP	ST @2g/kg seed
T_4- tebuconazole 50% + trifloxystrobin 25% WG	FS @ 1.5g/L water
T_5- carbendazim 12% + mancozeb 63% WP	FS @ 2g/L water
T_{6-} captan 70WP	FS @ 2g/L water
T_7- tebuconazole 50% + trifloxystrobin 25% WG	ST @ 1.5g/kg seed +SD @ 1.5 g/L water
T_{8-} carbendazim 12% + mancozeb 63% WP	ST @ 2g/kg seed +SD @ 2g/L water
T_9- captan 70%WP	ST @ 2g/kg seed +SD @ 2g/L water
T_{10}-*Trichoderma harzianum*	ST @ 10g/kg seed +SA @ 10 kg/ha
T_{11}- *Pseudomonas fluorescens*	ST @ 10g/kg seed +SA @ 10 kg/ha
T_{12-} Control	

*FS=Foliar spray, *ST= Seed treatment, *****SA= Soil application, SD=Soil drenching

Total 12 treatments including control were tested following randomized block design having plot size of 3 x 3 m^2. Each treatment was replicated thrice. The experiment was conducted under artificial soil infestation conditions. For this purpose, sand maize meal inoculum of *M. phaseolina* was applied at 50g per plot and mixed properly on top surface soil using a hand rack. Standard agronomic practices recommended for cultivation of cowpea crop was followed. In case of control, the untreated plots were sown with sterilisedseeds. Observations on charcoal rot incidence were recorded periodically as well as the grain yield was recorded after harvesting of the crop.

Calculation and Statistical Analysis

Per cent disease incidence (PDI) and per cent disease control were calculated as follows:

$$\text{Disease incidence (\%)} = \frac{\text{No. of diseased plants}}{\text{Total no. of plants germinated}} \times 100$$

$$\text{Disease control (\%)} = \frac{\text{Disease incidence in control (\%)} - \text{Disease incidence in treatment(\%)}}{\text{Disease incidence in control (\%)}} \times 100$$

The data of per cent disease incidence were transformed to their arc sine values (Fisher and Yates, 1963). The statistical analysis of field experiments was analyzed following randomized block design (Cochran and Cox, 1957).

RESULTS AND DISCUSSION

Effect of bio-agents and fungicides under field conditions

The charcoal rot incidence in cowpea was significantly reduced in fungicidal treatments of tebuconazole 50% + trifloxystrobin 25% WG (11.36%) followed by carbendazim 12% + mancozeb 63% WP (13.09%) when used as seed treatment in combination with soil drench (Table 1 and Fig 1). The disease control was also recorded highest in tebuconazole 50% + trifloxystrobin 25% WG (82.20%) followed by carbendazim 12% + mancozeb 63% WP (79.49%). This is due to the fact that at an early stage when seed treatment is applied, fungicides inhibit *M. phaseolina* present in seed and later on soil drench effectively check the systemic infection by pathogen. Seed treatment with fungicides showed highest disease control in tebuconazole 2DS (70.44%) followed by carbendazim 12% + mancozeb 63% WP (67.05%). Foliar spray showed promising results but it was comparatively less effective than seed treatment and soil drench together. The maximum control through foliar spray was observed by tebuconazole 50% + trifloxystrobin 25% WG (60.09%) followed by carbendazim 12% + mancozeb 63% WP (59.77%). Bio-agents minimized the incidence of disease but to a lower extent than fungicides.Among the bioagents, *T. harzianum* showed significantly higher disease control of 56.66% followed by *P. fluorescens*, which controlled the disease up to 49.89%.Our findings corroborate with the findings reported by Lokesha and Benagi (2007), Kumari *et al*. (2012), Khalili *et al*. (2016) and Meena *et al*. (2018).

Grainyield

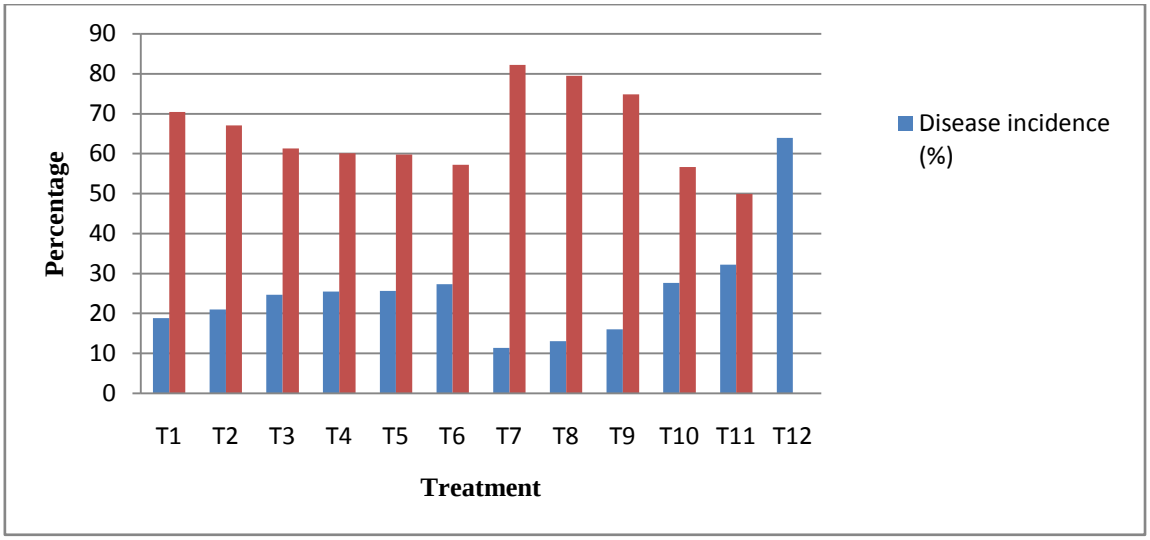
Highest grain yield of cowpea (14.90 qha^{-1}) was obtained in tebuconazole 50% + trifloxystrobin 25% WG followed by carbendazim 12% + mancozeb 63% WP (13.45 qha^{-1}) when applied as seed treatment in combination with soil drench (Table 1). Grain yield recorded from seed treatment with fungicides was 12.40 qha^{-1} fromtebuconazole 2DS followed by 11.52qha^{-1} fromcarbendazim 12% + mancozeb 63%

WP. As regards to foliar spray, it was found less effective than seed treatment and seed treatment + soil drench. Grain yield recorded from foliar spray with fungicides was 10.81 qha^{-1} fromtebuconazole 50% + trifloxystrobin 25% WG followed by 10.02 qha^{-1} from carbendazim 12% + mancozeb 63% WP. Seed treatment with*T. harzianum*and *P. fluorescens*in combination with their soil application resulted in 9.22 and 9.01 qha^{-1} yield respectively. The reduction in soil borne plant diseases and subsequent enhancement in the yield of different crops after treatment with formulations of *T. harzianum* have been reported by several workers (Harman *et al.*, 2004and Jaiman*et al.*, 2009).

Table 1. Management of charcoal rot of cowpea through different bio-agents and fungicides under field conditions

Treatment	Dose	Disease incidence (%)	Disease Control (%)	Yield (qha^{-1})
T_1- tebuconazole 2DS	ST @ 1.5 gkg^{-1} seed	18.86 (25.73)*	70.44	12.40
T_2- carbendazim 12% + mancozeb 63% WP	ST @ 2g kg^{-1} seed	21.02 (27.29)	67.05	11.52
T_3- captan 70% WP	ST @2gkg^{-1} seed	24.68 (29.78)	61.33	10.19
T_4- tebuconazole 50% + trifloxystrobin 25% WG	FS @ 1.5gL^{-1} water	25.46 (30.30)	60.09	10.81
T_5- carbendazim 12% + mancozeb 63% WP	FS @ 2gL^{-1} water	25.67 (30.43)	59.77	10.02
T_6- captan 70% WP	FS @ 2gL^{-1} water	27.31 (31.42)	57.23	9.31
T_7- tebuconazole 50% + trifloxystrobin 25% WG	ST @ 1.5gkg^{-1} seed +SD @ 1.5 gL^{-1} water	11.36 (19.69)	82.20	14.90
T_8- carbendazim 12% + mancozeb 63% WP	ST @ 2gkg^{-1} seed +SD @ 2gL^{-1} water	13.09 (21.21)	79.49	13.45
T_9- captan 70% WP	ST @ 2gkg^{-1} seed +SD @ 2gL^{-1} water	16.05 (23.61)	74.84	12.85
T_{10}- *Trichoderma harzianum*	ST @ 10gkg^{-1} seed +SA @ 10 kgha^{-1}	27.67 (31.73)	56.66	9.22
T_{11}- *Pseudomonas fluorescens*	ST @ 10kg^{-1} seed +SA @ 10 kgha^{-1}	32.25 (34.58)	49.89	9.01
T_{12}- Control		63.94 (53.20)	0.00	6.20
S.Em± CD (P=0.05) CV (%)		2.04 5.98 13.79		0.69 2.03 11.10

*Figure in parenthesis are angular transformed values



CONCLUSION

In recent years cultivation of cowpea has decreased due to major constraint of charcoal rot disease. In ourstudy the charcoal rot incidence in cowpea was least in fungicidal treatments of tebuconazole 50% + trifloxystrobin 25% WG when used as seed treatment in combination with soil drench thus disease control

was recorded highest.Conclusively, application of the fungicides in combination with seed treatment and soil drench of tebuconazole 50% + trifloxystrobin 25% WG enhanced the yield more effectively as compared to other fungicides and bioagent treatment.

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