

Research Paper

Control of soil borne diseases of chickpea with new generation fungicides

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ABSTRACT

Chickpea crop is affected by numerous diseases from the seedling to maturity stage, among which soil-borne diseases viz. *Fusarium wilt*, dry root rot, and collar rot directly affect and reduce the chickpea grain yield. Taking this into consideration, the efficacy of six fungicides wastested against the major soil-borne pathogens under laboratory and field conditions. Under laboratory conditions, the fungicide carboxin 37.5% + thiram 37.5% WS was found to be most effective against the chickpea pathogens, viz. *Fusarium oxysporum* f. sp. *ciceri*, *Rhizoctonia bataticola* and *Sclerotium rolfsii* with 93.20, 94.89 and 85.23 percent mycelial growth inhibition, respectively followed by treatment of carbendazim 25% + mancozeb 50% WS. Under field conditions, the treatment carboxin 37.5% + thiram 37.5% WS@ 4gm/kg produced a significant reduction in soil-borne diseases with the highest grain yield which was at par with the treatment of carbendazim 25% + mancozeb 50 WS @ 3gm/ kg.

Key words: Chickpea, Soil-borne diseases, Seed treatment, New fungicides

INTRODUCTION

Pulses are major constituents in Indian farming and consumption patterns and are regarded as “poor man’s meat” due to their lower cost as a source of protein. Among the various pulse crops cultivated throughout the world, chickpea is the third-largest pulse crop next to beans (*Phaseolus vulgaris* L.) and peas (*Pisum sativum* L.). India ranks 1st in area and production of the chickpea crop in the world. Among the various states of India, Maharashtra ranks 1st in chickpea area (2.7 m ha) and production (3.10 mt) with 25.13% and 22.90% contribution, respectively in the country’s total area and production. The other major states in terms of chickpea production are Madhya Pradesh (19.77%), Rajasthan (19.37%), Gujarat (10.67%) and Uttar Pradesh (7.01%) (Anonymous 2023). Recently, a major reduction in chickpea yield has been observed due to biotic stresses imposed by insects, bacteria, fungi, nematodes, and viruses. Among biotic stresses wilt complexes caused by soil-borne pathogens namely, wilt (*Fusarium oxysporum* f. sp. *ciceri*), root and stem rot (*Rhizoctonia bataticola*), collar rot (*Sclerotium rolfsii*) are responsible for a significant reduction in productivity in arid and semi-arid regions (Nene *et al.* 1981).

This complex disease is present in various forms, including seed rot, seedling blight, root rot, and mature plant wilt, ultimately leading

to production losses ranging from 60-70%. The pathogens responsible for these three diseases being mostly soil-borne, are very difficult to manage because these soil-inhibiting pathogens survive in the soil for years even in the absence of a suitable host. An efficient management strategy against wilt complex pathogens should involve the integration of various cultural, physical, and biological methods along with the use of efficient fungicides as seed treatment agents that can protect the seedlings from soil-borne pathogens. Fungicides can eradicate the pathogens that have already been established as well as give protection to seedlings from pathogens. Traditionally seed treatment with fungicides like thiram, captan, and carbendazim is recommended for chickpea seeds for management of soil-borne diseases. However, nowadays new fungicide molecules are available in the market which may show enhanced potential against the soil-borne pathogens of chickpea. Thus, the present study was carried out to assess the efficacy of new seed-treating fungicides in controlling the wilt complex disease of chickpea.

MATERIALS AND METHODS

Isolation of chickpea pathogens

Chickpea plants showing typical symptoms of soil-borne diseases were collected from fields

of Pulse Improvement Project, MPKV, Rahuri. A standard tissue isolation procedure was followed to isolate the pathogens. The isolated pathogens were identified based on morphological and cultural characteristics and pathogenicity. Three distinct pathogens, *viz.* *Fusarium oxysporum* f. sp. *ciceri*, *Sclerotium rolfsii* and *Rhizoctonia bataticola* were obtained from the diseased samples.

In vitro evaluation of fungicides against the pathogens

Efficacy of six fungicides against the three fungal pathogens, *viz.* *Fusarium oxysporum* f. sp. *ciceri*, *Rhizoctonia bataticola*, *Sclerotium rolfsii* was evaluated *in-vitro* by applying the poison food technique and using potato dextrose agar as basal culture medium. Fungicide-amended PDA medium plates were inoculated aseptically with a five-disc obtained from a week-old actively growing pure culture of test pathogens. Three replications per treatment were maintained and plates were incubated at $27 \pm 2^\circ\text{C}$. After seven days of incubation, the mycelial growth of the test pathogens in each treatment was measured and percent mycelial growth inhibition was calculated by applying the following formula (Vincent 1927).

$$\text{Per cent growth inhibition} = \frac{C-T}{C} \times 100$$

Where,

C= growth of the test fungus in control plates (mm)

T= growth of the test fungus in treated plates (mm)

Evaluation of fungicides under field condition

The fungicides evaluated under *in vitro* conditions were also evaluated under field conditions for their efficacy to control the soil-borne disease infecting chickpea crop. The field trial was conducted during the *Rabi* season 2022-23 at the experimental farm of Pulses Improvement Project, MPKV, Rahuri (19.35° North, 74.65° West) having medium black soil type. Rainfall received during the crop period was 168.4 mm in 11 rainy days. The experiment was laid out in randomized block design with three replications on chickpea variety JG-62. Seed treatment with test fungicides was done before sowing at recommended doses. After sowing, observations on germination, numbers of wilted plants at periodic intervals, and yield in each treatment were recorded.

Percent disease incidence (PDI) was computed by applying the following formula :

$$\text{Percent disease incidence (PDI)} = \frac{\text{Number of wilted plants}}{\text{The total number of plants observed}} \times 100$$

Percent disease control (PDC) over untreated control was calculated by applying the following formula :

$$\text{Percent Disease Control (PDC)} = \frac{C-T}{C} \times 100$$

Where, C=disease incidence in untreated control plot, T=disease incidence in treated plot

RESULTS AND DISCUSSION

Three different soil-borne diseases employed in the present study produced distinct symptoms and also appeared at different crop growth stages. Based on the symptoms on plants and morphological and cultural characteristics, isolated pathogens were identified as *Fusarium oxysporum* f. sp. *ciceri*, *Sclerotium rolfsii* and *Rhizoctonia bataticola*. The pathogenicity of the pathogens was proved on chickpea variety JG-62 by sick soil method under glasshouse conditions.

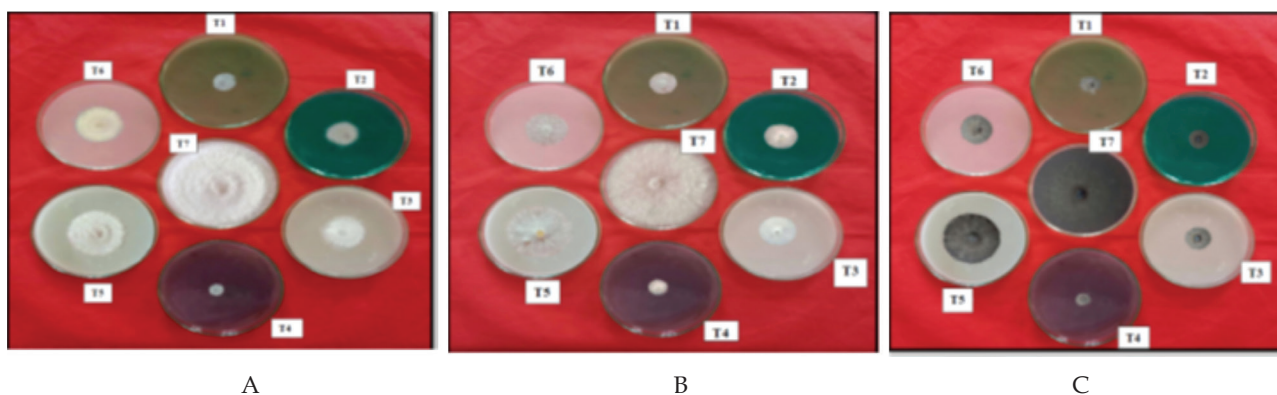
In-vitro efficacy of fungicides against soil borne pathogens

The efficacy of six fungicides was tested under *in vitro* conditions by poison food technique.

Efficacy of fungicides against Fusarium oxysporum f. sp. ciceri

The performance of all fungicides was significantly superior over control in inhibiting the mycelial growth of *Fusarium oxysporum* f. sp. *ciceri*. However, significant inhibition of colony diameter (5.83 mm) was recorded in the treatment of carboxin 37.5 % + thiram 37.5% WS @ 0.2% followed by treatment of carbendazim 25% + mancozeb 50 WS @ 0.15% (6.13 mm) with 93.52 and 93.19 percent inhibition of the pathogen, respectively. The other fungicide treatments, i.e. thiophanate methyl 45% + pyraclostrobin 5% F.S @ 0.2%, prochloraz 5.7% + tebuconazole 1.4% w/w ES @ 0.15% and carbendazim 50% WP @ 0.1% also gave promising control with 83.11, 81.74 and 70.96 percent growth inhibition of pathogen, respectively (Table 1, Plate 1 A).

The efficacy of different combi, non-systemic, and systemic fungicides in inhibiting the mycelial growth of *Fusarium oxysporum* f. sp. *Cicero* under *in-vitro* conditions has been reported previously by many workers. Khan *et al.* (2012) reported maximum inhibition of the pathogen with thiram, carbendazim, and prochloraz while Ravichandran



A

B

C

Plate 1. Mycelial growth inhibition by various fungicides: (A) *Fusarium oxysporum* f. sp. *cicero*, (B) *Sclerotium rolfsii* and (C) *Rhizoctonia bataticola*

[Note: T1- Carbendazim 25% + Mancozeb 50 WS; T2- Thiophanate methyl 45% + Pyraclostrobin 5% FS; T3- Prochloraz 5.7% + Tebuconazole 1.4% w/w ES; T4- Carboxin 37.5% + Thiram 37.5% WS @ 0.2; T5- Tebuconazole 5.4% w/w FS; T6- Carbendazim 50% WP; T7- Control (untreated)]

and Hegade (2015) reported efficacy of combi products carbendazim + mancozeb and zineb + hexaconazole, contact fungicides copper oxychloride and zineb and among systemic fungicides, carbendazim and tebuconazole in inhibiting the mycelial growth of *Fusarium oxysporum* f. sp. *cicero*. Patra and Biswas (2016) and Thaware *et al.* (2016) reported that carbendazim completely inhibited the mycelial growth of *Fusarium oxysporum* f. sp. *cicero*. Nandeesh and Huilgol (2021) reported that among the non-systemic, systemic, and combi fungicides evaluated copper oxychloride, carbendazim, and carbendazim + mancozeb were most efficient for growth inhibition of *Fusarium oxysporum* f. sp. *cicero*, respectively.

Efficacy of fungicides against Sclerotium rolfsii

All the fungicides recorded significantly less colony diameter than the control treatment (Table 1, Plate 1B) in inhibiting the mycelial growth of *Sclerotium rolfsii*. Minimum colony diameter (11.87 mm) with maximum i.e. 86.81 percent inhibition of mycelial growth was recorded in the treatment of carboxin 37.5% + thiram 37.5% WS @ 0.2% which was at par with treatment of carbendazim 25% + mancozeb 50 WS @ 0.15% which recorded 13.63 mm mean colony diameter with 84.65 percent mycelial growth inhibition. However, the lowest inhibition was observed in the treatment of tebuconazole 5.4% w/w FS @ 0.2% (48.79%). Earlier studies conducted by Kumar *et al.* (2011) reported that under *in vitro* conditions carboxin, carbendazim and metalaxyl showed 100% inhibition of *Sclerotium rolfsii* causing collar rot of chickpea. Systemic fungicides

hexaconazole, propiconazole and difenoconazole and nonsystemic fungicide mancozeb were reported to be highly effective in inhibiting mycelial growth of *Sclerotium rolfsii* by Manu and Nagaraja (2012). Sangeeta *et al.* (2022) reported that among the systemic fungicides, hexaconazole and propiconazole inhibited the growth of the pathogen completely under *in-vitro* conditions.

Efficacy of fungicides against Rhizoctonia bataticola

Similarly, the performance of the fungicides was also found superior in controlling *Rhizoctonia bataticola*. Maximum growth inhibition (95.44) percent with minimum colony diameter (4.10 mm) was recorded in the treatment of carboxin 37.5% + thiram 37.5% WS @ 0.2% and was at par with carbendazim 25% + mancozeb 50 WS @ 0.15% with colony diameter of 5.13 mm and 94.30 percent growth inhibition. The other treatments i.e. thiophanate methyl 45% + pyraclostrobin 5% F.S @ 0.2%, prochloraz 5.7% + tebuconazole 1.4% w/w ES @ 0.15%, and carbendazim 50% WP @ 0.1% also gave promising results where in 8.67 mm, 9.13 mm and 14.33 mm mean colony diameter of a fungus with 90.37, 89.85 and 84.07 percent inhibition, respectively was recorded. However, least inhibition (51.74%) was recorded with tebuconazole 5.4% w/w FS @ 0.2% (Table 1, Plate 1C).

Khan *et al.* (2012) reported complete inhibition of *Rhizoctonia bataticola* (causal agent of dry root rot of chickpea) under *in-vitro* conditions with mancozeb, carbendazim and copper oxychloride. Chaudhary (2017) observed 100% inhibition of

chickpea dry root pathogen under laboratory conditions with carbendazim and mancozeb. Similarly, complete inhibition of mycelial growth of *Rhizoctonia bataticola* with combi fungicides carbendazim + mancozeb and carboxin + thiram, contact fungicides chlorothalonil and mancozeb and systemic fungicides carbendazim, difenoconazole and tebuconazole was reported by Ravichandran and Hegade (2017). Bankoliya *et al.* (2022) reported that combi fungicides carboxin + thiram and carbendazim + mancozeb completely inhibited the mycelial growth of *Rhizoctonia bataticola*.

The present study indicated that under *in vitro* conditions, new-generation combi fungicides

are comparatively more efficient in inhibiting the mycelial growth of soil-borne pathogens infecting chickpea crops than the alone systemic fungicides tebuconazole and carbendazim. Though the efficacy of widely used systemic fungicides carbendazim has been reported previously by many workers; the present investigation emerged with the superiority of new combi fungicides for growth inhibition of *Fusarium oxysporum* f. sp. *ciceri*, *Sclerotium rolfsii* and *Rhizoctonia bataticola*.

Efficacy of fungicides against soil-borne pathogens of chickpea under field condition

A field trial was conducted to test the efficacy

Table 1. Efficacy of fungicides against the soil-borne pathogens of chickpea under *in vitro* condition.

Treatment	<i>Fusarium oxysporum</i> f. sp. <i>ciceri</i>		<i>Sclerotium rolfsii</i>		<i>Rhizoctonia bataticola</i>	
	Mean colony diameter (mm)	Percent inhibition	Mean colony diameter (mm)	Percent inhibition	Mean colony diameter (mm)	Percent inhibition
Carbendazim 25% + Mancozeb 50 WS @ 0.15%	6.13	93.19	13.63	84.85	5.13	94.30
Thiophanate methyl 45% + Pyraclostrobin 5% F.S @ 0.2%	15.20	83.11	16.23	81.96	8.67	90.37
Prochloraz 5.7% + Tebuconazole 1.4% w/w ES @ 0.15%	16.43	81.74	18.33	79.63	9.13	89.85
Carboxin 37.5% + Thiram 37.5% WS @ 0.2%	5.83	93.52	11.87	86.81	4.10	95.44
Tebuconazole 5.4% w/w FS @ 0.2%	38.27	57.48	49.77	44.70	43.43	51.74
Carbendazim 50% WP @ 0.1%	26.13	70.96	21.33	76.30	14.33	84.07
Control	90.00	-	90.00	-	90.00	--
SEm±	0.97	-	0.72	-	0.68	-
CD (P=0.05)	2.93	-	2.20	-	2.08	-

Table 2. Disease incidence of soil-borne pathogens of chickpea in various treatments.

Seed treatment	Germination (%)	Percent disease incidence (%)				Percent disease control	Yield (kg/ha)
		30 DAS	60 DAS	75 DAS	90 DAS		
Carbendazim 25% + Mancozeb 50 WS @ 3 gm/kg	96.55	1.33 (6.60)*	2.42 (8.90)	4.97 (12.88)	7.38 (15.49)	79.22	1149
Thiophanate methyl 45%+ Pyraclostrobin 5% F.S @ 4 ml/kg	96.23	1.33 (6.60)	2.5 (8.94)	6.14 (14.34)	9.05 (17.31)	74.52	1051
Prochloraz 5.7% + Tebuconazole 1.4% w/w ES @ 3 ml/ kg	95.82	1.5 (7.03)	3.07 (10.07)	7.38 (15.76)	12.73 (20.81)	64.16	1023
Carboxin 37.5 % + Thiram 37.5% WS @ 4 gm/kg	97.25	1.03 (5.82)	1.70 (7.18)	3.71 (11.10)	6.12 (13.95)	82.77	1226
Tebuconazole 5.4% w/w FS @ 4 ml/ kg	94.98	1.84 (7.78)	3.50 (10.77)	11.09 (19.45)	18.38 (25.92)	48.25	712
Carbendazim 50% WP @ 2 gm/kg	95.10	1.70 (7.48)	3.10 (10.02)	9.27 (17.72)	14.95 (22.65)	57.91	801
Untreated control	94.48	7.83 (16.17)	11.39 (19.71)	21.19 (27.40)	35.52 (36.55)	-	-
SEm±	-	1.03	1.06	1.36	1.3	-	0.63
CD (P=0.05)	-	3.18	3.27	4.20	4.02	-	1.90

*Figures in parentheses are arc sine transformed values

of fungicides for controlling soil-borne diseases infecting chickpea crops. Chickpea seeds were treated with respective fungicides and after emergence; observations on germination, and disease incidence were recorded at periodic intervals and after crop maturity grain yield of each plot was recorded separately. The results are presented in Table 2.

Germination

Seed treatment with various fungicides had no significant effect on seed germination and all treatments were at par with each other. However, maximum (97.25%) seed germination was recorded in the fungicide seed treatment of carboxin 37.5% + thiram 37.5% WS @ 4 gm/kg seed of seed which was followed by treatment of carbendazim 25% + mancozeb 50 WS @ 3 gm/kg seed and thiophanate methyl 45%+ pyraclostrobin 5% F.S @ 4 ml/kg seed with 96.55% and 96.23% seed germination, respectively. Minimum germination i.e. 94.48% was recorded in untreated control.

Disease incidence and its control

Incidence of collar rot and *Fusarium* wilt was mainly observed under field conditions. Dry root rot incidence was negligible. Moreover, collar rot incidence was more prominent during the early crop growth period (upto 30 days) whereas, wilt incidence was recorded throughout the crop growth period. From the data presented in Table 2, it is revealed that chickpea seed treatment with fungicides under study significantly reduced the incidence of soil-borne diseases over untreated control. The treatment of carboxin 37.5% + thiram 37.5% WS @ 4 gm/kg seed recorded the least disease incidence i.e. 1.03, 1.71, 3.71, and 6.12% at 30, 60, 75, and 90 DAS, respectively. It was followed by treatment of carbendazim 25% + mancozeb 50 WS @ 3 gm/kg seed with 1.33, 2.42, 4.97, and 7.38 percent disease incidence at 30, 60, 75 and 90 DAS, respectively. Accordingly, the highest disease control (82.77%) was recorded with treatment of carboxin 37.5% + thiram 37.5% WS @ 4 gm/kg seed followed by treatment of carbendazim 25% + mancozeb 50 WS @ 3 gm/kg seed (79.22%). The next best treatment was thiophanate methyl 45% + pyraclostrobin 5% F.S @ 4 ml/kg seed which recorded 9.05% disease incidence at 90 DAS with 74.52% disease control. Seed treatment with prochloraz 5.7% + tebuconazole 1.4% w/w ES @ 3 ml/ kg seed and carbendazim 50% WP @ 2gm/kg seed also showed promising results for control of diseases with 64.16 and 57.91% disease

control. Among all the fungicides, seed treatment with tebuconazole 5.4% w/w FS @ 4 ml/kg seed was comparatively less effective as it recorded 18.38% disease incidence at 90 DAS and 48.25% disease control. The highest disease incidence i.e. 35.52 was recorded in untreated control treatment.

Yield

Chickpea seed treatment with fungicides under study significantly increased the yield of the crop over untreated control. The treatment of carboxin 37.5% + thiram 37.5% WS @ 4 gm/kg seed recorded maximum yield i.e. 1226 kg/ha. It was followed by treatment of carbendazim 25% + mancozeb 50 WS @ 3 gm/kg seed and thiophanate methyl 45%+ pyraclostrobin 5% F.S @ 4ml/kg seed with 1149 kg/ha and 1051 kg/ha yield respectively. The minimum yield i.e. 542 kg/ha was recorded in untreated control.

Earlier, Magar (2012) reported the effectiveness of seed treatment with propiconazole, penconazolethiophanate methyl, and hexaconazole in minimizing chickpea wilt incidence. Thakur *et al.* (2002) reported that carbendazim, benomyl, and captan as seed treatment were effective in lowering collar rot infection in chickpeas. The effectiveness of combi fungicides to control chickpea wilt and collar rot diseases has been also previously reported by a few workers. Baker (1988) reported that seed dressing with carbendazim + thiram significantly reduced collar rot disease in chickpeas. Golakiya *et al.* (2018) reported that carbendazim 12% + mancozeb 63% WP seed treatment showed minimum percent disease incidence of chickpea wilt. Nathawat and Kumari (2022) reported maximum control of collar rot disease in chickpeas with seed treatment carbendazim + thiram @ 2 gm/kg seed.

Present studies also emerged with findings that seed treatment with combi fungicides significantly controlled the soil-borne diseases in chickpea crops. Maximum control of the diseases was obtained with seed treatment of carboxin 37.5% + thiram 37.5% WS @ 4 gm/kg seed. It was followed by carbendazim 25% + mancozeb 50 WS @ 3 gm/kg seed and thiophanate methyl 45%+ pyraclostrobin 5% F.S @ 4 ml/kg seed.

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