ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2026): 4.97
IJAFS 2026; 8(5): 473-481
www.agriculturaljournals.com
Received: 25-03-2026
Accepted: 27-04-2026

Premlata
Student of M.Sc. (Agri.) Plant Pathology, Department of Plant Pathology, Faculty of Agriculture Science and Technology, AKS University, Satna, Madhya Pradesh, India

Hemlata Sahu
Student of M.Sc. (Agri.) Plant Pathology, Department of Plant Pathology, Faculty of Agriculture Science and Technology, AKS University, Satna, Madhya Pradesh, India

Doomar Singh
Head, Department of Plant Pathology, AKS University, Satna, Madhya Pradesh, India

Corresponding Author:
Premlata
Student of M.Sc. (Agri.) Plant Pathology, Department of Plant Pathology, Faculty of Agriculture Science and Technology, AKS University, Satna, Madhya Pradesh, India

In vitro evaluation of fungicides and bioagents against *Sclerotium rolfsii*, causing collar rot of chickpea

Premlata, Hemlata Sahu and Doomar Singh

DOI: https://www.doi.org/10.33545/2664844X.2026.v8.i5f.1543

Abstract
Madhya Pradesh is leading state in chickpea productivity but due to diseases it is continuously decreasing. Different fungicides are used by the farmers to reduce the losses caused by these diseases. In an *in vitro* evaluation of Metalaxyl 4% + Mancozeb 64%, Carbendazim 12% + Mancozeb 63%, Carboxin 37.5% + Thiram 37.5%, and Propiconazole 13.9% + Difenoconazole 13.9% against *Sclerotium rolfsii*, causing collar rot of chickpea were highly effective, exhibited complete inhibition of fungal growth at all tested concentrations and time intervals. Thiram 75% exhibited 89.44% and 86.44% inhibition with at 0.15% and 0.2% concentrations respectively. Copper oxychloride 50% showed 38.66, 21.85, 18.83% inhibition with 0.25% concentration at 3, 5 and 7 DAI respectively while carbendazim 50% and *Pseudomonas fluoresces* 1% WP were ineffective. All tested concentrations of Neem oil (0.5, 1.0 and 1.5%) inhibited *Sclerotium rolfsii* growth from 76.32 to 84.46% and *Trichoderma viride* also inhibited the *S. rolfsii* fungus growth upto 61.23 - 68.93% when inoculated on same day with *Sclerotium rolfsii.*

Keywords: Collar rot, chickpea, DAI, *Pseudomonas florescence sclerotium rolfsii*, *Trichoderma viride*

Introduction
Pulses are the source of vegetarian protein in Indian food. Chickpea (*Cicer arietinum* L.) is significant pulse crop contributing about 27% of global production (ICAR - Indian Institute of Pulses Research) which provides 23% protein, 64% carbohydrates and essential minerals (Miao *et al.*, 2009) [7]. In India chickpea is grown in 9.12 Mha with total production of 11.11 MT and productivity 1218 kg/ha (Anonymous, 2024-25) [1]. In Madhya Pradesh total area under chickpea production is 1.35Mha, (14.84% of total area of the country), total production is 2.11MT (18.98%) and productivity is 1558 Kg/ha. (Anonymous, 2024-25) [1]. Madhya Pradesh is the third leading state in chickpea area, second in total production and first in productivity (Anonymous, 2024-25) [1]. As compare to cropping year 2023-24, area and production under chickpea in MP (2.11Mha and 2.91MT respectively) has been decreased because the crop has been increasingly threatening by various fungal diseases for last many years like- Ascochyta blight (*Ascochyta rabiei)*, Botrytis gray mold (*Botrytis cinerea),* Alternaria blight (*Alternaria alternata),* Colletotrichum blight (*Colletotrichum dematium),* Phoma blight (*Phoma medicaginis),* Rust (*Uromyces ciceris-arietini),* Powdery mildew (*Leveillula Taurica),* Sclerotinia stem rot (*Sclerotinia sclerotiorum),* Fusarium wilt (*Fusarium oxysporum* f. sp. *Ciceri,* Verticillium wilt (*Verticillium albo-atrum),* Collar rot (*Sclerotium rolfsii),* Dry root rot (*Sclerotium rolfsii),* Phytophthora root rot (*Phytophthora medicaginis),* Foot rot (*Operculella padwickii)* (ICRISAT 2012 or Nene *et.al*., 2012) [9].
Since, Collar rot caused by *Sclerotium rolfsii* was a minor disease but from last few years it is becoming major disease causing quantitative and qualitative losses. In Vindhyan plateau of Madhya Pradesh 12.00-18.20% disease incidence was recorded during 2018 and 2019 cropping seasons (Singh *et.al*., 2022) [17]. Rolfs (1892) [12] first time reported *Sclerotium rolfsii* as a causal organism of tomato blight in Florida. The causal organism of tomato blight was first time given by Saccardo (1911) [14]. The pathogen survives as macrosclerotia in soil and infects roots when plants are under abiotic stress. *In vitro* effect of temperature and pH shows that fungus survives best at 30^{0}C and at pH 5.5-7.0 (Premlata *et.al*. 2025) [11].

These environmental and soil conditions not found only in Madhya Pradesh but also found in many other States like U.P., Bihar, Haryana, Punjab, Maharashtra, therefore, this disease may prevalent in these states also. The aim of the present study was to know the effect of different fungicides and bio-agents control/management collar rot of chickpea disease caused by *Sclerotium rolfsii.*

2. Materials and Methods

2.1 Survey of disease

A survey was conducted to record the occurrence and distribution of collar rot of chickpea in Sohawal block, Satna in central India - Madhya Pradesh, during the Rabi season of 2024-25. Chickpea plants displaying typical collar rot symptoms were collected from the surveyed areas, packed in labelled polythene bags and were brought to the laboratory for pathogen isolation.

2.2 Isolation and Purification of Fungus from Infected Roots: The fungus was isolated and purified from infected roots by using Potato Dextrose Agar (PDA) medium having pH 6 (Premlata *et.al*., 2025) [11] in sterilized Petri dishes. The inoculated Petri dishes were incubated at 27 ± 2°C in a BOD incubator to promote fungal growth for further microscopic examination. Based on morphological characteristics of the mycelium and sclerotia the isolates were identified as *Sclerotium rolfsii*. The pure cultures were stored on PDA slants in a refrigerator at 4 ± 1°C for further studies.

2.3. *In vitro* Evaluation of Different Fungicides Against *Sclerotium rolfsii:* An *in vitro* study was carried out to evaluate the efficacy of seven chemical fungicides and three biocontrol agents *Trichoderma viride*, neem oil, and *Pseudomonas fluorescens* (Table 1) against *Sclerotium rolfsii*, the causal agent of collar rot in chickpea. The poisoned food technique was employed using Potato Dextrose Agar (PDA) having pH 6 as the basal medium. Fresh (24hours to 48 hours old) and pure culture of *Trichoderma viride* was inoculated at four points around the disc of *Sclerotium rolfsii,* on the same day (T_1), after one day (T_2) and after 2days (T_3). The radial growth of tested fungus, *Sclerotium rolfsii* was measured upto 5 days after inoculation. Based on the active ingredient concentration the required quantity of each fungicide was accurately weighed and mixed thoroughly into autoclaved and cooled PDA medium (approx. 40°C) in conical flasks to achieve the desired concentrations. Twenty millilitres of each fungicide-amended medium was poured aseptically into 90 mm sterile glass Petri dishes and allowed to solidify at room temperature. Each plate was then inoculated at the centre with a 5 mm mycelial disc cut from the actively growing margin of a 7-day-old *Sclerotium rolfsii* culture and placed in an inverted position in BOD incubation. Control plates (without fungicide or biocontrol agents) were also inoculated with the same culture to serve as untreated controls. Three replications were maintained for each treatment. Plates were incubated at 30^0C temperature (Premlata *et.al*., 2025) [11]. After incubation the two directional mycelium growth (in cm**)** of the fungus (*Sclerotium rolfsii*) was measured and mean of two direction growth was calculated. The percent inhibition of mycelial growth was calculated using the following formula:

$$\text{Percent Growth Inhibition} = \frac{C-T}{C} \times 100$$

Where,

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

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

Table 1: Various fungicides and biocontrol agents used for fungal inhibition

S. No.	Trade Name	Technical Name	Company	Dilutions (in%)			
1.	Bavistin	Carbendazim 50%WP	Crystal Crop Protection	0.01	0.02	0.03	0.04
2.	Copper king	Copper Oxychloride50%WP	Srikar Biotech Pvt. Ltd	0.10	0.15	0.20	0.25
3.	Kavacham	Carbendazim 12% + Mancozeb 63% WP	Shanmukha Agritec Ltd	0.10	0.15	0.20	0.25
4.	Ridomil Gold	Metalaxyl 4% +Mancozeb 64% WP	Syngenta Crop Protection	0.10	0.15	0.20	0.25
5.	Thiram	Thiram 75% WP	Meenakshi Agro Chemicals	0.10	0.15	0.20	0.25
6.	Vitavax Power	Carboxin 37.5% + Thiram 37.5%WP	Dhanuka Agritech Pvt. Ltd.	0.10	0.15	0.20	0.25
7.	Glo-iT	Propiconazole 13.9% + Difenoconazole 13.9%EC	Syngenta Crop Protection	0.15	.02	.025	0.03
8.	-	*Trichoderma viride*	AKS University				
9.	Bheem	Neem oil	Neemanjali	0.5	1.0	1.5	2.0
10.	Sparsha	*Pseudomonas fluoresces* 1.0% WP	Multiplex Group	1.0	1.5	2.0	-

2.4. Statistical Analysis: The data obtained in the laboratory as well as open top chamber experiments were analyzed by Completely Randomized Design.

ANOVA Table for CRD

Source of Variation	Degrees of Freedom (df)	Sum of Squares (SS)	Mean Squares (MS)	F-ratio
Treatments	t - 1	TSS	$TMS=\frac{TSS}{t-1}$	$\frac{TSS}{EMS}$
Error	n-t	ESS	$EMS=\frac{ESS}{n-1}$	
Total	n-1	SS		

For pair comparisons the CD value is compared as

Critical Difference (C.D.) = t-value at error d.f. X Standard Error of diff. (SEd)

Where,

$SEd= \sqrt{EMS}\ (1/r_i + 1/r_j)$

3. Results

3.1 Survey and Symptoms of Disease

The survey was conducted from mid Dec.-mid Jan. 2025. The disease caused by *Sclerotium rolfsii*, was observed in many fields with varying degrees of severity. The infected seedlings turned slightly yellow before death and found scattered throughout the field was an indication of collar rot infection. The disease was seen mostly at the seedling stage particularly in high soils moisture. Young seedlings were collapsed due to sophisticated stage but older seedlings were completely dry without collapsing and having leaves attached to the plant. Infected plants were easily uprooted due to rotting of secondary roots from collar region to downwards of the root. The rotten portion of the root was found covered with whitish mycelial strands.

3.2 Isolation and Identification of the Fungus (*Sclerotium rolfsii*): Collar rot causing fungus (*Sclerotium rolfsii*) isolated from infected plants on PDA. The isolated fungus grown on PDA medium exhibited higher radial growth which filled 90 mm diameter petri plates within 5 days. The colony colour of *Sclerotium rolfsii* appeared cottony white with dense radiating mycelial growth (Fig. 1A) and numerous brown to dark brown macro-sclerotia were developed throughout the mycelial mat (Fig. 1B). The hyphal cells of *Sclerotium rolfsii* were septate and hyaline.

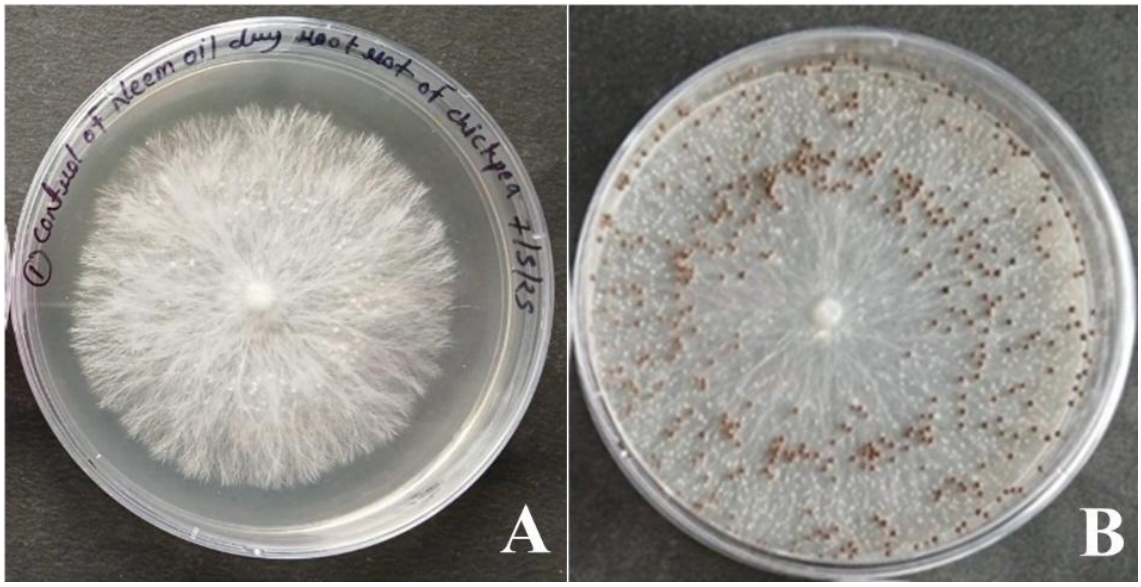

Fig 1: *Sclerotium rolfsii;* Mycelium on PDA A) and sclerotia B)

3.3 Effect of Different Fungicides on the growth of the *Sclerotium rolfsii*

3.3.1 Effect of Copper oxychloride 50% on the Growth of *Sclerotium rolfsii*

The results presented in Table 2 and figure 2 revealed the impact of varying concentrations of copper oxychloride 50% WP on the radial growth of *Sclerotium rolfsii* at 3, 5 and 7 days after inoculation (DAI).

Table 2: Effect of different concentrations of Copper oxychloride 50% on radial growth of *Sclerotium rolfsii*

Treatment (concentration)	Mean inhibition (%)		
	3 DAI	5 DAI	7 DAI
0.01%	8.30	5.60	4.74
0.15%	15.74	4.98	1.50
0.20%	30.20	17.20	16.14
0.25%	38.66	21.85	18.83
Control	0.00	0.00	0.00
SEm±	6.03	4.66	4.10
C.D.(p=0.01)	19.27	14.88	13.07
C.V. (%)	56.29	81.33	86.06
F - Cal.	6.84	3.87	4.47
F- Tab	3.17	3.17	3.17

The maximum fungal growth inhibition (38.66, 21.85 and 18.83%) at 3, 5 and 7 respectively was found with 0.25% (T_4) concentration (Table 2) followed by (30.20, 17.20 and 16.14%) at 0.20% (T_3) concentration at 3, 5 and 7 DAI with 0.20% concentration of copper oxychloride (Table 2). A similar trend was also observed with lower concentration (0.15%).

Although growth inhibition was very low but Copper-oxychloride 50% WP significantly inhibited the growth of *Sclerotium rolfsii* (Fig. 2).

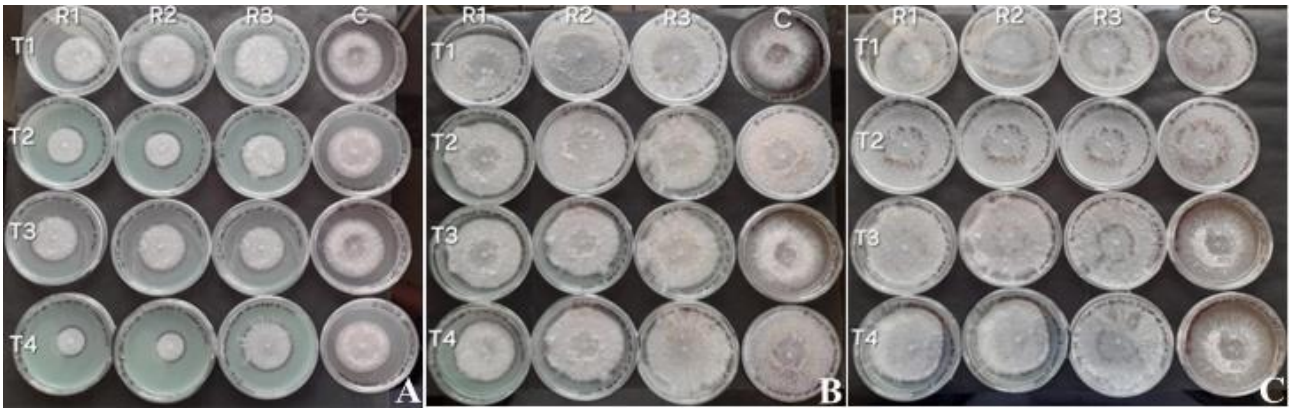

Fig 2: Effect of different concentrations of copper-oxychloride 50% on radial growth of *Sclerotium rolfsii* at; 3DAI A), 5DAI B) and 7 DAI C)

3.3.2 Effect of Carbendazim 50% on the Growth of *Sclerotium rolfsii*

Carbendazim 50% WP exerted a less inhibitory effect on the mycelial growth of the pathogen (*Sclerotium rolfsii*) at 3, 5 and 7 DAI (Table 3).

The highest inhibition (20.58%) was observed with 0.04% (T_4) concentration followed by (12.32%) with 0.03% (T_3) at 3 DAI but there was not significant inhibition at 5DAI with all concentrations. However, at 7 DAI, three treatments (T_1, T_2 and T_3) showed very similar radial growth inhibition (5.56%, 5.56% and 5.00% respectively) and T_4 showed negligible inhibition (1.11%) which was not significant (Fig. 3).

Table 3: Effect of different concentrations of Carbendazim 50% on radial growth of *Sclerotium rolfsii*

Treatment (concentration)	Mean inhibition (in%)		
	3 DAI	5 DAI	7 DAI
0.01%	9.40	0.59	5.56
0.02%	4.37	0.00	5.56
0.03%	12.32	0.39	5.00
0.04%	20.58	0.00	1.11
Control	0.00	0.00	0.00
SEm±	4.28	0.28	0.45
C.D.(p=0.01)	N/A	N/A	1.45
C.V. (%)	79.32	244.53	22.81
F - Cal.	3.38	1.00	34.79
F-Tab	3.169	3.169	3.169

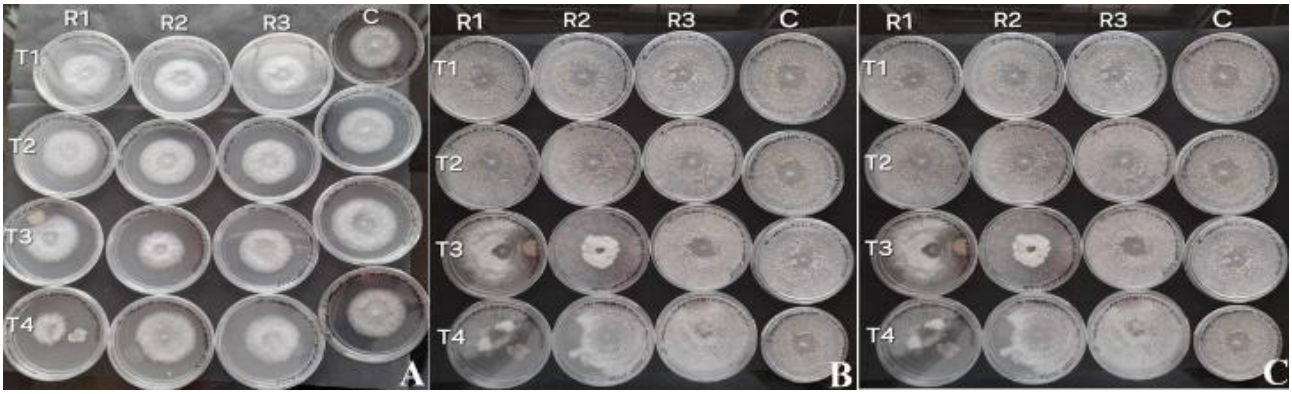

Fig 3: Effect of different concentrations of carbendazim 50% on radial growth of *Sclerotium rolfsii* at; 3DAI A), 5DAI B) and 7 DAI C)

3.3.3 Effect of Thiram 75% on the Growth of *Sclerotium rolfsii:*

Maximum growth inhibition of *Sclerotium rolfsii* by Thiram 75% WP with 0.15 (98.02, 96.78 and 73.53% at 3, 5 and 7 DAI respectively) and with 0.20% (93.01, 83.44 and 82.86% at 3, 5 and 7 DAI respectively) was found (Table 4). Statistical analysis confirmed that all treatments (0.1/T_1, 0.15/T_2, 0.2/T_3 and 0.25% /T_4) were significantly inhibited the growth of *Sclerotium rolfsii* when compared to the control (Fig. 4) across all three observation intervals (3, 5, and 7 DAIs) but 0.15 (T_2) and 0.20% (T_3) have given best results (Fig. 4).

Table 4: Effect of different concentrations of Thiram 75% on radial growth of *Sclerotium rolfsii*

Treatment (concentration)	Mean inhibition (in%)		
	3 DAI	5 DAI	7 DAI
0.1%	93.32	74.71	72.55
0.15%	98.02	96.78	73.53
0.2%	93.01	83.44	82.86
0.25%	87.59	80.69	79.96
Control	0.00	0.00	0.00
SEm±	2.909	3.474	2.281
C.D.(p=0.01)	9.285	11.089	7.280
C.V. (%)	6.773	8.965	6.395
F - Cal.	205.97	122.05	232.84
F-Tab	3.169	3.169	3.169

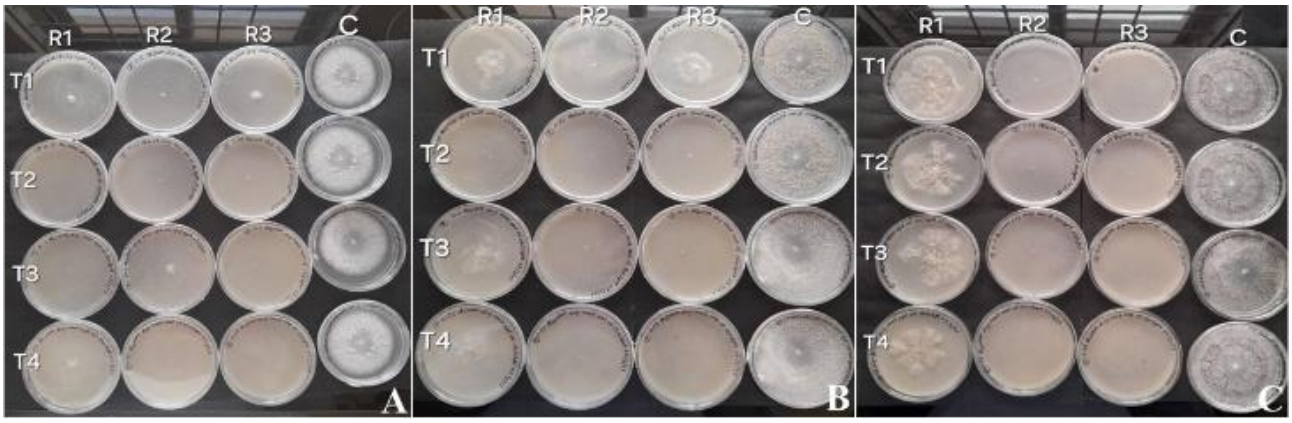

Fig 4: Effect of different concentrations of thiram 75% on radial growth of *Sclerotium rolfsii* at; 3DAI A), 5DAI B) and 7 DAI C)

3.3.4 Effect of different concentrations of Metalaxyl 4% + Mancozeb 64% on radial growth of *Sclerotium rolfsii*

The present study revealed that all tested concentrations of Metalaxyl 4% + Mancozeb 64% (0.1%, 0.15%, 0.2%, and 0.25%) were completely inhibited the radial growth of *Sclerotium rolfsii* at 3, 5, and 7 DAI. No fungal growth inhibition was recorded in untreated (control) petri plates (Fig. 5) at any intervals.

The consistency of complete inhibition across all concentrations and time points indicated that the fungicidal combination of Metalaxyl 4% + Mancozeb 64% possesses strong and sustained antifungal activity against *Sclerotium rolfsii*.

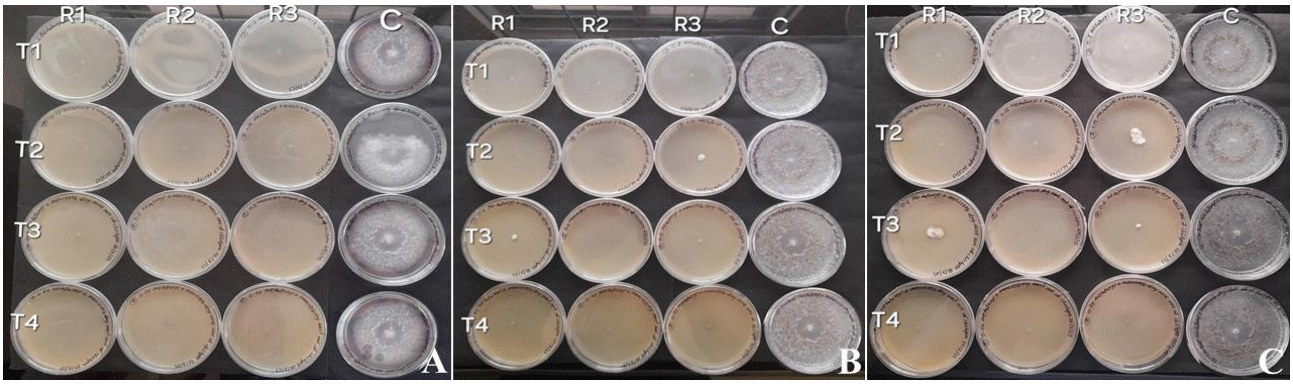

Fig 5: Effect of different concentrations of Metalaxyl 4% + Mancozeb 64% on radial growth of *Sclerotium rolfsii* at; 3DAI A), 5DAI B) and 7 DAI C)

3.3.5 Effect of Carbendazim 12% + Mancozeb 63% on the Growth of *Sclerotium rolfsii:*

At all-time intervals (3, 5 & 7 DAI) and all tested concentrations (0.1%, 0.15%, 0.2%, and 0.25%) of Carbendazim12% + Mancozeb 63% (SAAF) completely inhibited the mycelial growth of *Sclerotium rolfsii* (Fig. 6). In contrast, the untreated control recorded normal radial growth (zero percent growth inhibition). These findings indicated that Carbendazim 12% + Mancozeb 63% is highly effective in arresting the initial growth of the pathogen even at the lowest concentration tested.

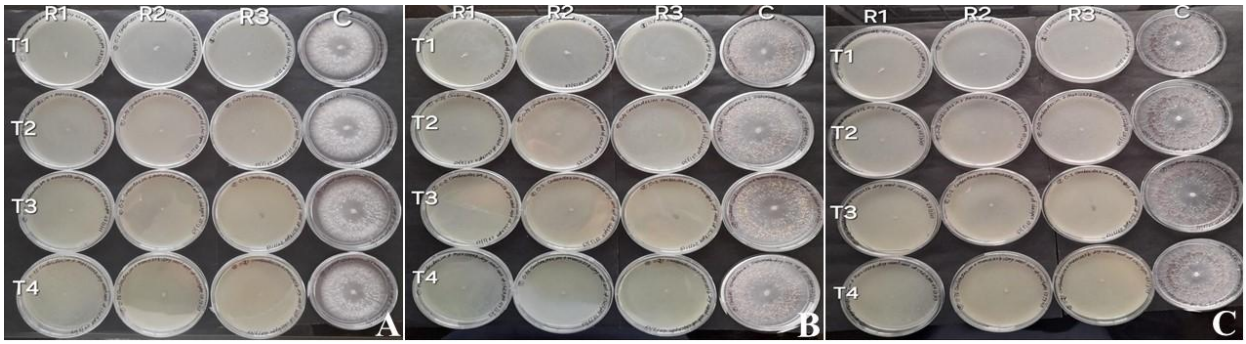

Fig 6: Effect of different concentrations of Carbendazim12% + Mancozeb 63% on radial growth of *Sclerotium rolfsii* at; 3DAI A), 5DAI B) and 7 DAI C)

3.3.6 Effect of Carboxin 37.5% + Thiram 37.5% on the Growth of *Sclerotium rolfsii:*

The impact of Carboxin 37.5% + Thiram 37.5% at different concentrations (0.1%, 0.15%, 0.2%, and 0.25%) on the radial growth of *Sclerotium rolfsii* was assessed at 3, 5 and 7 DAI which exhibited complete inhibitory effect (Fig. 7) on the mycelial growth of the pathogen (*Sclerotium rolfsii*).

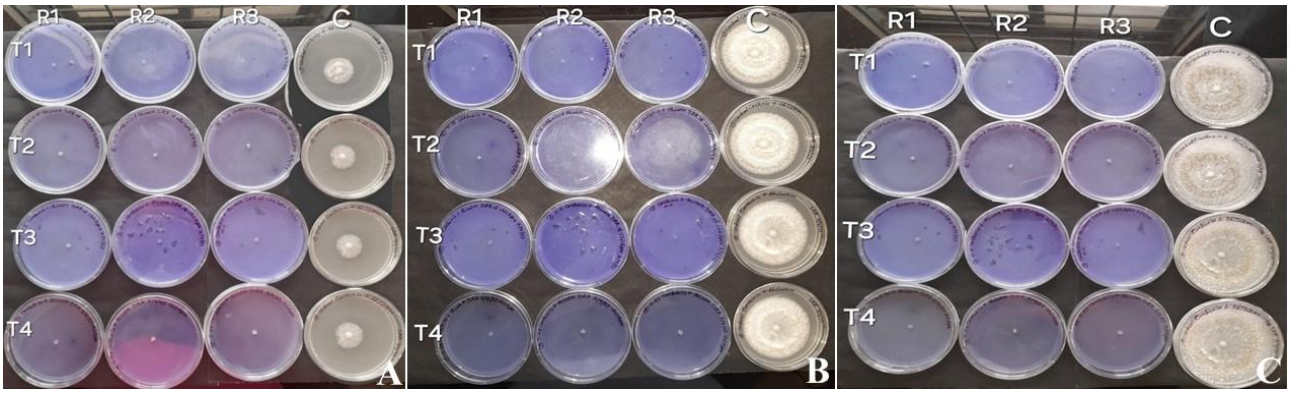

Fig 7: Effect of different concentrations of Carboxin 37.5% + Thiram 37.5% on radial growth of *Sclerotium rolfsii* at; 3DAI A), 5DAI B) and 7 DAI C)

3.3.7 Effect of Propiconazole 13.9% + Difenoconazole 13.9% on the Growth of *Sclerotium rolfsii:*

The results shown in Fig. 8 revealed that Propiconazole 13.9% + Difenoconazole 13.9% at tested concentrations (0.015%/T_1, 0.02%/ T_2, 0.025%/T_3, and 0.03%/T_4) and at all tested time intervals (3, 5 and 7 DAI) completely restricted the radial growth of *Sclerotium rolfsii* (100% inhibition) while untreated (control) PDA medium showed significant mycelial growth without inhibition at all time intervals (3, 5 and 7 DAI). These results described that Propiconazole 13.9% + Difenoconazole 13.9% has strong and sustained antifungal activity against *Sclerotium rolfsii*.

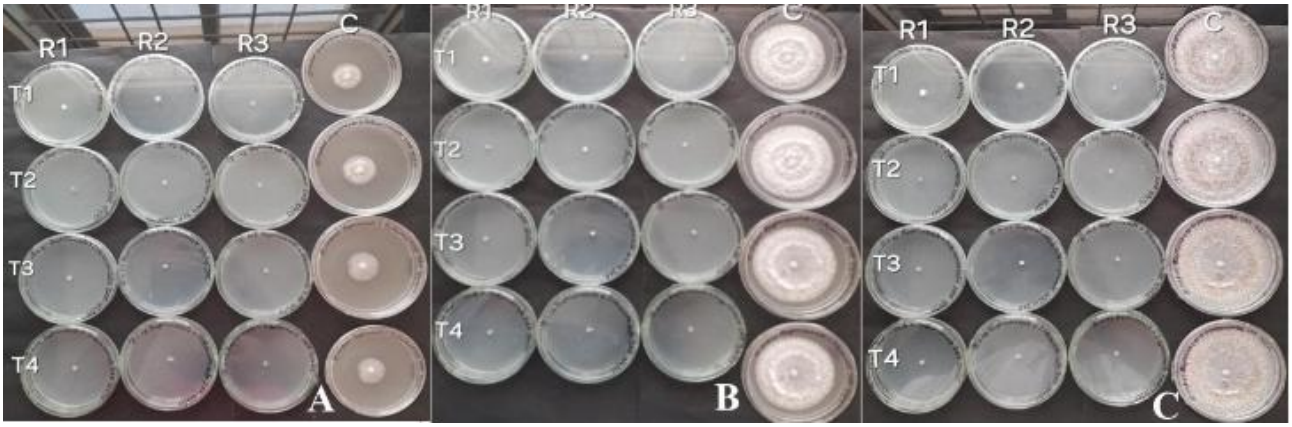

Fig 8: Effect of different concentrations of Propiconazole 13.9% + Difenoconazole 13.9% on radial growth of *Sclerotium rolfsii* at; 3DAI A), 5DAI B) and 7 DAI C)

3.3.8 Effect of *Pseudomonas fluorescens* on the Growth of *Sclerotium rolfsii*

It was shown that maximum fungal growth inhibition was found with only 1% concentration of *Pseudomonas fluorescence* at 3 DAI (Table 5 and Fig. 9) but not at any other concentration (1.5 and 2.0%). At 5 and 7 DAI there was no inhibition with any concentration (1.0%/T_1, 1.5%/T_2 and 2.0%/T_3) of *Pseudomonas fluorescence* (Fig. 9). It is confirmed that *Pseudomonas fluorescence* 1% can inhibit *Sclerotium rolfsii* at only early stages.

Table 5: Effect of *Pseudomonas fluorescence* on the Growth of *Sclerotium rolfsii*

Treatment (concentration)	Mean inhibition (in%) at 3 DAI				
	R_1	R_2	R_3	R_4	Mean
1.0%	14.81	13.46	16.98	12.15	14.35
1.5%	7.40	0.00	0.00	4.67	3.01
2.0%	5.56	0.00	5.66	2.80	3.50
Control	0.00	0.00	0.00	0.00	0.00
SEm±					1.24
C.D (p=0.01)					3.88
C.V. (%)					47.76
F- Cal					25.40
F - Tab					5.95

This indicated that the inhibitory effect observed at 3 DAI diminished over time and *Pseudomonas fluorescens* had a limited or transient impact on the pathogen (*Sclerotium rolfsii)* under the given experimental conditions.

Fig 9: Effect of different concentrations of *Pseudomonas fluorescens* on radial growth of *Sclerotium rolfsii* at; 3DAI A), 5DAI B) and 7 DAI C)

3.3.9 Effect of Neem oil on the growth of *Sclerotium rolfsii:*
The antifungal efficacy of Neem oil with all tested concentrations/treatments (0.5%/T_1, 1.0%/T_2 and 1.5%/T_3) was evaluated against *Sclerotium rolfsii* through poison bait technique shown the results in Table (6) and Figure (10).
At 3 DAI**,** all concentrations/treatments (0.5%/T_1, 1.0%/T_2 and 1.5%/T_3) showed increasing inhibition of fungal growth (80.47, 82.48 and 84.46% respectively). The same trend of inhibition (77.94, 80.14 and 81.47%) was found at 5 DAI with all tested concentrations (Table 6) but at 7 DAI growth inhibition of the tested fungus was not found same as at 3 and 5 DAI. However, neem oil indicated statistically significant inhibition of *Sclerotium rolfsii* at all time period intervals (3, 5 and 7 DAI).
Overall, Neem oil exhibited a strong, dose-dependent antifungal activity with 1.5% concentration being the most effective in reducing the mycelial growth of *Sclerotium rolfsii* across all observations.

Table 6: Effect of Neem oil on the growth of *Sclerotium rolfsii*

Treatment (concentration)	Mean inhibition (in%)		
	3 DAI	5 DAI	7 DAI
0.5%	80.47	77.94	76.32
1.0%	82.48	80.14	80.44
1.5%	84.46	81.47	78.67
Control	0.00	0.00	0.00
SEm	1.101	0.514	1.189
C.D.(p=0.01)	3.431	1.602	3.705
C.V(%)	3.561	1.711	4.041
F - Cal.	1,404.30	6,040.07	1,090.70
F-Tab	3.055	3.055	3.055

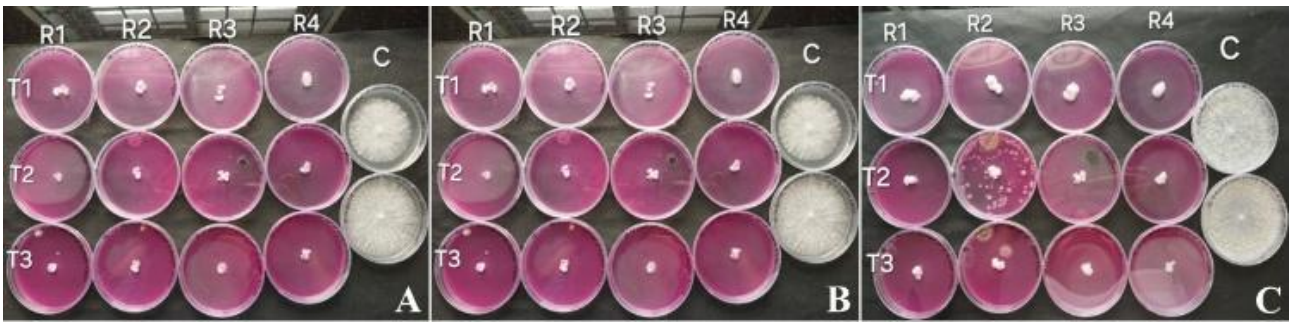

Fig 10: Effect of different concentrations of Neem oil on radial growth of *Sclerotium rolfsii* at; 3DAI A), 5DAI B) and 7 DAI C)

Effect of *Trichoderma viride* on the Growth of *Sclerotium rolfsii:* When *Trichoderma viride* and *Sclerotium rolfsii* were inoculated same day (T_1) the inhibition of was found 68.93% at 5 DAI (Table7) but when *Trichoderma viride* was inoculated one and two days after inoculation of *Sclerotium rolfsii,* the inhibition was found 30.40% and 20% respectively (Table 7) at 5 DAI. The results presented in Table 7 along with Figure10 indicated that *Trichoderma viride* had a marginal inhibitory effect on the mycelial growth of the pathogen. However, *Trichoderma viride* checked further growth of *Sclerotium rolfsii* in T_2 and T_3 treatments (Fig. 11). Present study showed that *Trichoderma viride* has antagonistic effect against *Sclerotium rolfsii.* Statistical analysis was not possible due to size of the experiment (Only 3 treatments and 3 replications) but mean inhibition percent was calculated.

Table 7: Effect of *Trichoderma viride* on the growth of *Sclerotium rolfsii*

Treatments	Mean inhibition (in%)				
	1 DAI	2 DAI	3 DAI	4DAI	5DAI
T_1	0.56	61.23	68.32	66.71	68.93
T_2	1.68	18.00	29.28	30.43	30.40
T_3	0.56	1.06	18.88	22.57	20.00
Control	0.00	0.00	0.00	0.00	0.00

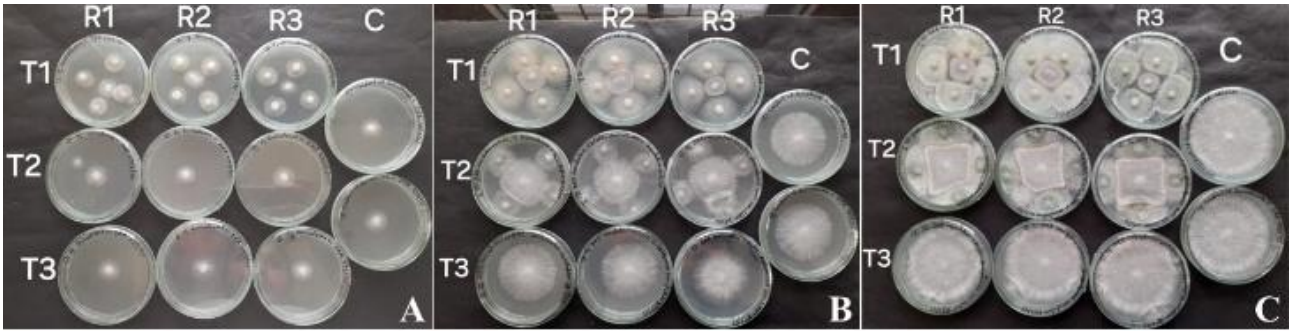

Fig 11: Effect of *Trichoderma viride* on radial growth of *Sclerotium rolfsii* at; 0 DAI (T_1) A), 1 DAI (T_2) B) and 2 DAI (T_3) C)

Discussion

Among all fungicides tested, Metalaxyl 4% + Mancozeb 64%, Carbendazim 12% + Mancozeb 63% (SAAF), Carboxin 37.5% + Thiram 37.5%, and Propiconazole 13.9% + Difenoconazole 13.9% were highly effective, exhibiting complete inhibition of fungal growth (Fig. 3.5, 3.6 and 3.7) at all tested concentrations and time intervals (3, 5, and 7 DAI). These results indicated a strong and broad-spectrum fungicidal activity of these systemic and contact fungicides against *Sclerotium rolfsii.* Similarly, Divyashree *et.al*. (2024) [3] observed that Carboxin 37.5% + Thiram 37.5% and Carbendazim 12% + Mancozeb 63% were highly effective in preventing sclerotial germination and mycelial spread of *S. rolfsii*. Carbendazim 12% + Mancozeb 63% was also found most effective in inhibiting complete mycelial growth of *S. rolfsii* (Kumari *et.al*. 2023) [5]. Shirsole *et.al*. (2019) [16] also found 100% inhibition of mycelial growth of *Sclerotium rolfsii* treated with Propiconazole 13.9% + Difenconazole13.9% EC at the rate of 50ppm, 100ppm and 150ppm. Carbendazim 12% + Mancozeb 63% (0.15%) and Carboxin 37.5% + Thiram 37.5% also showed cent per cent inhibition (Sangeeta *et.al*., 2022 and Shirsole *et.al*., 2019) [15, 16] as in present study. Thiram 75% WP exhibited moderate antifungal activity. The maximum growth inhibition (72.55% to 98.02%) was observed at all tested concentrations of Thiram 75% (0.1, 0.15, 0.20 and 0.25%) at 3 to 7 DAI. The present findings are supported by Kumar *et.al*. (2021) [4] that Thiram exhibited moderate antifungal activity (33.33%) against *Sclerotium rolfsii* in chickpea with 150ppm concentration. Carbendazim 50%, a commonly used systemic fungicide exhibited limited and inconsistent inhibition of *S. rolfsii* especially at higher concentrations (0.03% and 0.04%) where no significant difference was found as compare to control. Rothe *et.al*. (2019) [13] found 56.13% inhibition of *S. rolfsii* growth by Carbendazim 50% WP. *Pseudomonas fluorescens* (1% concentration) exhibited a significant inhibitory effect (14.5%) on the radial growth of *Sclerotium rolfsii* at only 3 days after inoculation (DAI) but other concentrations (1.5 and 2.0%) did not show significant inhibition (Fig. 3.8). Kumar *et.al*. (2021) [4] found 76.3%, Meena *et.al.* (2023) [6] found 68.89% and Bagul *et.al*, (2024) [2] found 74.04% mycelial growth inhibition of *S. rolfsii* with *Pseudomonas fluorescence.* Neem oil exhibited strong and sustained antifungal activity against *S. rolfsii* at all tested concentrations (0.5, 1.0 and 1.5%) consistently up to 76.32 - 84.46% (Table 6). Singh *et.al*. (2023) [18] also recorded up to 47.22 and 59.44% mycelial growth inhibition of *S. rolfsii* at 10 and 15% concentrations of NSKE. *Trichoderma viride* also exhibited a progressive (61.23-68.93%) and consistent antagonistic effect against *Sclerotium rolfsii* from 2 to 5 DAI (Table 7). These findings are in close agreement with those of Prajapati *et.al*. (2015) [10] who reported complete inhibition of *S. rolfsii* radial growth by *T. viride.* Kumar *et.al.* (2021) [4] observed 72.22% inhibition of *S. rolfsii* while Meena *et.al.* (2023) [6] found 78.61% growth inhibition of *S. rolfsii* by *T. viride.* These are closely related to the present findings. In another experiment 63.33% inhibition of *S. rolfsii* fungus causing collar rot of chickpea was recorded by Nagamma and Nagaraja (2015) [8].

Collar rot of chickpea caused by *Sclerotium rolfsii* has become a serious problem for chickpea producing farmers due to similarity with wilt caused by *Fusarium oxysporum* f. sp. *Ciceri* and dry root rot caused by *Rhizoctonia bataticola*. The farmers have been using few numbers of fungicides, bioagents and botanicals only for management of wilt disease for many years but not for collar rot disease. The present study can give the multiple options for management of collar rot disease of chickpea.

Acknowledgements
We acknowledge the AKS University, Satna, M.P., India for undertaking the different activities of research presented in this manuscript.

Conflict of Interest
Authors have declared that we have no competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Disclaimer (Artificial Intelligence)
Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

References

1. Anonymous. Government of India, Ministry of Agriculture and Farmers Welfare, Department of Agriculture and Farmers Welfare Economics, Statistics and Evaluation Division. Agricultural Statistics at a Glance 2024–25. 2025:75–78. https://nccd.gov.in/uploads/Agricultural_Statisitcs_at_a Glance_2024_25_11da3cd37d.pdf
2. Bagul VK, Hasabnis SN, Navale AM, Kolase SV, Satyam. Efficacy of different bioagents against collar rot disease of chickpea incited by *Sclerotium rolfsii* under *in vitro* conditions. Journal of Advances in Microbiology. 2024;24(5):1–5. doi:10.9734/jamb/2024/v24i5821.
3. Divyashree, Manjula CP, Anandakumar J, Punith G, Anusree K, *et al.* Morphological and cultural characterization of *Sclerotium rolfsii* Sacc. on chickpea and its management using combined fungicides molecules. Journal of Scientific Research and Reports. 2024;30(6):268–276. DOI:10.9734/jsrr/2024/v30i62041.
4. Kumar A, Mishra P, Khilari K, Singh G, Singh R, *et al.* Efficacy of bio-agents and fungicides against *Sclerotium rolfsii* Sacc. causing collar rot in chickpea (*Cicer arietinum* L.) *in vitro*. The Pharma Innovation Journal. 2021;10(10):1136–1139.
5. Kumari P, Gupta RN, Sah SB, Prasad S. Evaluation of fungicides against *Sclerotium rolfsii* incitant of collar rot disease of chickpea. Annals of Plant Protection Sciences. 2023;31(2):42–45. DOI:10.5958/0974-0163.2023.00021.6.
6. Meena PK, Sharma RS, Nain Y. Efficacy of bio-control agents against *Sclerotium rolfsii* causing collar rot disease of chickpea under *in vitro* conditions. Asian Journal of Microbiology, Biotechnology and Environmental Sciences. 2023;25(4):648–650. DOI:10.53550/AJMBES.2023.v25i04.007.
7. Miao M, Zhang T, Jiang B. Characterisation of chickpea starches from different varieties. Food Chemistry. 2009;113(2):306–312. DOI:10.1016/j.foodchem.2008.08.056.
8. Nagamma G, Nagaraja A. Efficacy of biocontrol agents against *Sclerotium rolfsii* causing collar rot disease of chickpea under *in vitro* conditions. International Journal of Plant Protection. 2015;8(2):222–227. DOI:10.15740/HAS/IJPP/8.2/222-227.
9. Nene YL, Reddy MV, Haware MP, Ghanekar AM, Amin KS, *et al.* Field diagnosis of chickpea diseases and their control. Information Bulletin No. 28 (Revised). Patancheru, AP: International Crops Research Institute for the Semi-Arid Tropics; 2012. p. 1–60.
10. Prajapati BK, Patel JK, Patil RK. Bio efficacy of *Trichoderma* spp. against *Sclerotium rolfsii* Sacc., an incitant of collar rot of chickpea *in vitro*. The Bioscan. 2015;10(4):1745–1748.
11. Premlata, Sahu H, Singh D, Lal M. *In vitro* effect of physicochemical properties on the growth of *Sclerotium rolfsii* Sacc. causing collar rot in chickpea (*Cicer arietinum* L.). International Journal of Plant and Soil Science. 2025;37(9):417–426. DOI:10.9734/ijpss/2025/v37i95719.
12. Rolfs PH. Tomato blight: some hints. Bulletin of Florida Agricultural Experimental Station. 1892;18:1–10.
13. Rothe AS, Mulekar VG, Kadam PN, Jaiswal KL, Shinde PA. Efficacy of systemic fungicides against *Sclerotium rolfsii* causing chickpea collar rot. International Journal of Chemical Studies. 2019;7(5):1147–1149.
14. Saccardo PA. Notae mycologicae. Annals Mycologicae. 1911;9:249–257.
15. Sangeeta N, Virupaksha Prabhu H, Balol G. *In vitro* evaluations of fungicides against *Sclerotium rolfsii* Sacc. causing collar rot of chickpea. International Journal of Plant Sciences. 2022;17(2):163–166. DOI:10.15740/HAS/IJPS/17.2/163-166.
16. Shirsole SS, Khare N, Lakpale N, Kotasthane AS. Evaluation of fungicides against *Sclerotium rolfsii* Sacc. incitant of collar rot of chickpea. The Pharma Innovation Journal. 2019;8(12):310–316.
17. Singh G, Khare UK, Babbar A, Wasnikar AR, Kumar A, *et al.* Present status of collar rot in major chickpea growing state of India. Biological Forum – An International Journal. 2022;14(2):1095–1101.
18. Singh K, Meena CB, Gautam C, Meena MK. Preliminary studies on bio-efficacy of different botanical extracts against *Sclerotium rolfsii* (Sacc.) causing collar rot of chickpea (*Cicer arietinum* L.). Legume Research. 2023;46(10):1392–1398. doi:10.18805/LR-4929.