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STUDIES ON MANAGEMENT OF SCLEROTINIA STEM ROT OF INDIAN MUSTARD (*BRASSICA JUNCEA* L. CZERN & COSS.) CAUSED BY *SCLEROTINIA SCLEROTIORUM* (LIB.) DE BARY

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ABSTRACT

Indian mustard, scientifically known as *Brassica juncea* L.Czern. Coss, is commonly referred to as *Rai* or *Laha* and belongs to the Brassicaceae family. India ranks third largest producer of rapeseed-mustard contributing approximately 14% to the global production. Fungal diseases pose a serious threat, leading to a decline in oilseed quality and reduced production. Indian mustard is susceptible to *Sclerotinia sclerotiorum* (Lib.) de Bary being the most severe, causing seedling mortality and rotting of stems and roots in mature plants. Managing Sclerotinia rot is particularly challenging due to its high saprophytic ability in the absence of a host, long-term soil survival as environmentally resistant sclerotia, broad host range, variability, and soil-inhabiting nature. Effective disease management requires an integrated approach combining chemical, biological and botanicals in an efficient way. *In vitro* studies demonstrated the superior efficacy of Carbendazim 12% WP + Mancozeb 63% WP in inhibiting mycelial growth when applied as a 0.1% foliar spray. This treatment also showed the highest seed yield in field conditions. Biological control using *Trichoderma harzianum* (0.5% soil application) significantly enhanced plant growth parameters, though with less disease suppression compared to chemical treatments.

Keywords **:** Saprophytic ability, sclerotia, integrated approach, *Trichoderma harzianum*

Introduction

Brassica juncea is one of the most important oilseed crops. It is widely cultivated in India for its pungent seeds used in oil extraction and spices. It is known for its drought tolerance and short growth cycle, playing a vital role in agriculture, food, and industry. It is widely grown as a self-sufficient crop and as an intercrop in marginal and sub-marginal soils, particularly in the eastern, northern and north-western parts of India. Additionally, it is cultivated in non-traditional areas of South India, such as Karnataka, Tamil Nadu and Andhra Pradesh. As a significant oilseed crop of the *Rabi* season, it thrives in certain tropical and subtropical regions as a cold-season crop. The plant requires cool, moist conditions for growth and dry, sunny weather for harvesting. It can be successfully cultivated under both irrigated and rainfed conditions (Saharan and Mehta, 2008). It is rich in protein, minerals and vitamins A and C, though its nutritional value can vary between species. Generally, it contains 1.3g of sugar, 4.51g of carbohydrates, 0.47g of fat, 4.4g of protein and 3.3g of dietary fiber per 100g (Nain *et al*., 2023). Oilseed *Brassica* typically have 38-57% erucic acid, 4.7-13% linolenic acid, 27% oleic and linoleic acids, which are essential for human health (Kumar *et al.,* 2014).

Mustard serves as a primary income source for marginal and small-scale farmers, predominantly

grown in rainfed and resource-challenged areas of the nation (Tripathi *et al*., 2023). It is cultivated on an area of 34.71 million hectares of land with the production of 73.21 million tonnes with an average yield of 2110 kg per hectare (Singh *et al.,* 2022). Indian mustard is predominantly cultivated in the states of Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh and Gujarat. Rajasthan ranks first in area and production of Indian mustard with 2.50 million ha area and 3.71 million tonnes production (Akshita Sharma *et al.,* 2025).

Indian mustard is susceptible to several soil-borne fungi, with *Sclerotinia sclerotiorum* (Lib.) de Bary being the most severe, causing seedling mortality and rotting of stems and roots in mature plants (Purdy *et al*., 1979). The symptom of Sclerotinia rot was noticed as water-soaked lesion on the main stem of plant in the initial stage within a week after infection, which soon turns into whitish brown large patches on the main stem, branches and inflorescence. The lesions finally girdled the stem completely (Sharma *et al*., 2015). The surface of affected parts including stem, branches and pods were covered with white cottony strands of the fungal mycelium. The mycelium produces sclerotia externally on affected plant parts and internally in stem pith. The signs of pathogen are apothecia, mycelium and sclerotial structure. Cup-shaped apothecia were developed on germination of sclerotia. Apothecia were brown in colour and were round to globate type (Husain and Choudhary *et al*., 2018). The sclerotia remain viable in the soil for many years. The internal symptom was observed by splitting the diseased plant parts at different stages of infection. The pith of stem becomes hollow in which irregular sized sclerotia were observed (Goswami *et al*., 2020). Plants infected during early flowering produce few or no seeds, while those infected later may still set seed with minimal yield loss (Kamran *et al*., 2019).

The disease has become one of the most widespread and destructive soil-borne diseases globally. In India, this disease has been reported in Rajasthan, Haryana, Punjab, Assam, West Bengal, Madhya Pradesh, Uttar Pradesh and Bihar due to these conditions (Yadav *et al*., 2013). Managing Sclerotinia rot is particularly challenging due to its high saprophytic ability in the absence of a host, long-term soil survival as environmentally resistant sclerotia, broad host range, variability and soil-inhabiting nature (Chamdam *et al*., 2023). Thus, management of disease through biocontrol agents, chemical methods and botanicals is an effective alternative to minimize environmental hazards and suppress this disease in the soil. Considering the severity of this disease in Indian mustard and its regular occurrence in fields, in depth, studies are required on integrated disease management.

Materials and Method

Experimental site

The present investigation was conducted in laboratory and Wire house of the Department of Plant Pathology, Chandra Shekhar Azad University of Agriculture and Technology in Kanpur, Uttar Pradesh (208002) during 2023-2025.

Isolation and purification of the pathogen

Small bits of diseased sample 2-3 mm dimension adjacent to healthy portion were cut, washed thoroughly in tap water followed by surface sterilization with 1 per cent sodium hypochlorite solution for 30seconds under aseptic condition inside the Laminar flow and washed thoroughly three times with distilled water to remove the chemical traces of sodium hypochlorite. The sclerotia were sterilized and transferred in potato dextrose agar medium poured Petri-dishes with the help of sterilized forceps. The Petri dishes were then transferred at 25±1°C in an incubator for 6 to 7 days to obtain the growth of the fungus. The purification of the isolated fungus was undertaken following hyphal tip technique and section cut technique (3 mm size of bit).

Maintenance of the cultures

To maintain the cultures of pathogen, were grown on sterilized PDA medium. The plates were inoculated with bit of 7 days old culture grown on potato dextrose agar at 25 ±1°C temperature. A set of pure culture was stored in refrigerator at 4°C and sub-culturing on potato dextrose agar was done at regular intervals.

In-vitro efficacy of botanicals against *Sclerotinia sclerotiorum*

The botanicals namely Neem leaf extract (*Azadirachta indica*) and garlic bulb extract (*Allium sativum*) were used against *Sclerotinia sclerotiorum* (L.) at different concentrations *viz*. 5 and 10 per cent using Poisoned food technique. The autoclaved extracts were mixed thoroughly with sterilized Potato Dextrose Agar (PDA) to a final concentration of 5% and 10% respectively. Approximately 20 ml of poisoned media was poured into 90 mm sterilized Petri plates and allowed to solidify in aseptic condition. All Petri plates were inoculated with actively growing 3 mm mycelial disc of *S. sclerotiorum*. Three replications were maintained for each treatment. These Petri plates were incubated at 25±1°C. The observation was recorded on pathogen radial growth at 24, 48 and 72 hours after inoculation.

In-vitro efficacy of bio-agents against *Sclerotinia sclerotiorum*

Efficacy of bio-agents against pathogen was tested using dual culture technique (Morton and Stroube, 1955). The observations were recorded based on radial growth of bio agents and isolated fungus *Sclerotinia sclerotiorum* at 24, 48 and 72 hours in dual culture.

Dual culture technique

In 90 mm diameter petri plates, 20 ml of sterilized and melted PDA was poured. After solidification of PDA, the mycelial disc of an antagonist (*Trichoderma harzianum* and *Trichoderma viride*) and fungal pathogen (*S. sclerotiorum*) were cut with the help of sterilized cork borer from 5-7 days old culture. A 5 mm mycelial disc of the pathogen was inoculated on one side and 5 mm mycelial disc of the *T. harzianum* and *T. viride* was inoculated on another side of the same Petri plate. Until full development in the control was seen, the plates were incubated at 25°C. The radial growth was measured at interval of 24 hours up to 7 days. Per cent inhibition over control was worked out using the formula given by Vincent (1947).

$$\text{Per cent inhibition of mycelial growth} = \frac{C - T}{C} x100$$

Where,

C = Growth of pathogen mycelium in control

T = Growth of pathogen mycelium in treatment

In-vitro efficacy of chemical against *Sclerotinia sclerotiorum*

Efficacy of two chemical fungicides, Propiconazole 25% EC and Carbendazim 12% WP + Mancozeb 63% WP were evaluated against *S. sclerotiorum* at 0.1 per cent concentration. The chemical fungicides were evaluated on potato dextrose agar medium using Poisoned Food Technique in laboratory. The required quantity of each fungicide was incorporated in Potato dextrose agar medium, thoroughly mixed by shaking prior to pouring in sterilized Petriplates and were allowed to solidify. These Petriplates were inoculated with 5 mm disc of seven days old culture of *S. sclerotiorum* in the Centre of the plate and incubated at 25±1ºC. Three replications of each fungicide were maintained.

Efficacy of botanicals, bioagents and fungicides against Sclerotinia stem rot of mustard under wire house condition.

Effect of plant leaf extracts, chemicals and bio-agents were tested as soil and foliar spray treatment against *Sclerotinia sclerotiorum*. Mass multiplied culture of *S. sclerotiorum* were properly mixed at 5g per kg of soil. Initially inoculated cultured pots were placed in favorable condition for seven days for multiplication of pathogenic mycelium. Each treatment was carried out with three replications. The effect of neem leaf extract and garlic bulb extract (@5% and 10%), Carbendazim 12% WP + Mancozeb 63% WP (0.1%), Propiconazole 25% EC (0.1%) as foliar sprays and Bio-agents such as *Trichoderma harzianum* (0.5%), *Trichoderma viride* (0.5%) as soil application was evaluated against Sclerotinia stem rot of mustard. The disease incidence and per cent disease control were calculated 45 days after sowing. The per cent of disease incidence were calculated according to formula given by Trapeor-Casas and Jimenez Diaz (1985).

$$\text{Per cent disease incidence} = \frac{\text{Total number of infected plants}}{\text{Total number of plants}} x100$$

Statistical analysis

Each treatment was replicated thrice and the values are means ± SE. The data were computed using SPSS software version 21.

Results

In vitro efficacy of different botanicals against *Sclerotinia sclerotiorum*

The results of effect of different botanicals are presented in Table-1 which revealed that *Allium sativum* (garlic) bulb extract demonstrated significantly greater inhibition of *Sclerotinia sclerotiorum* mycelial growth compared to *Azadirachta indica* (neem) leaf extract at both 5 and 10 per cent concentrations. After 24 hours, garlic extract at 5% and 10% concentration inhibited 11.95% and 21.28% of mycelial growth, respectively, while neem extract showed 2.79% and 17.78% inhibition. By 48 hours, garlic inhibition increased to 32.72% (5% concentration) and 47.40% (10%), whereas neem reached 28.10% (5%) and 42.59% (10%). After 72 hours, garlic further suppressed growth by 58.26% (5%) and 66.74% (10%), while neem achieved 51.00% (5%) and 64.55% (10%), confirming garlic's superior antifungal efficacy over time.

In-vitro efficacy of different bio-agents against *Sclerotinia sclerotiorum*

From Table-1 it was observed that after 24 hours of inoculation, the maximum mycelial inhibition of 52.76 per cent was observed in *Trichoderma harzianum*, followed by 39.94 per cent inhibition in *Trichoderma viride*. After 48 hours of inoculation, the maximum mycelial inhibition of 54.51 per cent was observed in *Trichoderma harzianum* followed by 51.94

per cent inhibition in *Trichoderma viride,* respectively. After 72 hours of inoculation, the maximum mycelial inhibition 70.60 per cent was observed in *Trichoderma harzianum,* followed by 66.90 per cent inhibition in *Trichoderma viride* respectively. The result revealed that *Trichoderma harzianum* is more effective in comparison to *Trichoderma viride.*

In-vitro efficacy of different chemical fungicides against *Sclerotinia sclerotium*

The results from table-1 indicates that after 24 hours of incubation, Carbendazim 12% WP + Mancozeb 63% WP showed maximum inhibition of the pathogen *i.e.*, 91.25 per cent mycelial growth of the pathogen, followed by 83.09 per cent inhibition in Propiconazole 25% EC. After 48 hours of inoculation, the maximum mycelial inhibition of 91.94 per cent was observed in Carbendazim 12% WP + Mancozeb 63% WP, followed by 87.87 per cent inhibition in Propiconazole 25% EC respectively. After 72 hours of inoculation, the maximum mycelial inhibition of 95.20 per cent was observed in Carbendazim 12% WP + Mancozeb 63% WP, followed by 93.60 per cent inhibition in Propiconazole 25% EC respectively. The result revealed that between the chemical fungicides, the Carbendazim 12% WP + Mancozeb 63% WP at 0.1 per cent concentration was found more effective than Propiconazole.

Table 1 : *In-vitro* evaluation of control measures against mycelial growth of *Sclerotinia sclerotiorum.*

Treatments	Conc.	24 hours		48 hours		72 hours	
		Mycelial growth of pathogen (mm)	% Inhibition	Mycelial growth of pathogen (mm)	% Inhibition	Mycelial growth of pathogen (mm)	% Inhibition
T_1=Neem leaf extract	5 %	16.61	2.79	27.67	28.12	49.00	51.00
T_2=Neem leaf extract	10 %	14.10	17.78	22.10	42.59	32.00	64.55
T_3=Garlic bulb extract	5 %	15.10	11.95	25.90	32.72	45.00	58.26
T_4=Garlic bulb extract	10 %	13.50	21.28	20.25	47.40	30.00	66.74
T_5=Propiconazole 25% EC	0.1%	2.90	83.09	4.67	87.87	6.40	93.60
T_6=Carbendazim 12% WP + Mancozeb 63% WP	0.1%	1.51	91.25	3.10	91.94	4.80	95.20
T_7= *Trichoderma harzianum*		8.10	52.76	17.51	54.51	25.10	70.60
T_8=*Trichoderma viride*		10.30	39.94	18.50	51.94	29.30	66.90
T_9=Control		17.15	0.00	38.50	0.00	90.00	0.00
C.D.		1.27	3.43	2.35	4.45	4.61	5.85
SE(m)		0.43	1.15	0.79	1.49	1.55	1.97
C.V		6.75	5.62	6.94	5.34	7.76	5.41

Efficacy of botanicals, chemicals and bioagents on morphological attributes of mustard under wire house condition

The study evaluated the efficacy of various treatments on mustard plant growth and yield parameters under wire house conditions, with all the treatments showing significant improvements compared to untreated controls (T9). *Trichoderma harzianum* (T7) emerged as the most effective treatment among morphological parameters, producing the maximum root length (3.4 cm), shoot length (6.3 cm), plant height (162.7 cm), number of siliquae per plant (56.9), siliqua length (6.3 cm) and number of seeds per siliqua (28). *Trichoderma viride* (T8) consistently demonstrated the second-best performance in these growth parameters. *T. harzianum* showed superior vegetative growth while the fungicide combination Carbendazim 12% WP + Mancozeb 63% WP (T6) produced the highest seed yield of 23.94 g/plant, followed by Propiconazole 25% EC (T5) of 22 g/plant and *T. harzianum* of 21.62 g/plant, all significantly outperforming the control yield of 14.20 g/plant. These findings suggest that bioagents, particularly *T. harzianum*, are most effective for enhancing plant growth and development, chemical treatments are more advantageous for maximizing seed yield, indicating potential benefits from an integrated approach combining both biological and chemical treatments in mustard crop.

Table 2 : *In-vivo* evaluation of botanicals, chemicals and bioagents on morphological attributes of mustard.

Number of Treatment	Name of Treatment	Conc.	Root length (cm)	Shoot length (cm)	Plant Height (cm)	Number of siliquae per plant	Length of siliqua (cm)	Number of seeds per siliqua	Seed yield per plant (gm)
T_1	Neem leaf extract	5%	2.5	4.6	118.0	42.0	5.2	15	17.23
T_2	Neem leaf extract	10%	2.7	5.2	137.2	48.9	5.7	18	18.34
T_3	Garlic bulb extract	5%	2.6	4.7	142.9	43.1	5.5	16	17.98
T_4	Garlic bulb extract	10%	2.8	5.5	149.0	50.0	5.8	21	19.00
T_5	Propiconazole 25% EC	0.1%	3.0	5.7	157.3	51.1	5.9	24	22.00
T_6	Carbendazim 12% WP + Mancozeb 63% WP	0.1%	3.1	5.8	158.2	52.0	6.0	25	23.94
T_7	*Trichoderma harzianum*	0.5%	3.4	6.3	162.7	56.9	6.3	28	21.62
T_8	*Trichoderma viride*	0.5%	3.2	5.9	160.1	54.2	6.2	26	21.10
T_9	Control	-	2.1	4.3	102.0	31.0	5.1	11	14.20
	C.D		0.26	0.50	13.43	4.46	0.54	1.92	1.79
	SE(m)		0.08	0.16	4.52	1.50	0.18	0.64	0.60
	C.V		5.44	5.47	5.47	5.45	5.49	5.48	5.37

Management of *Sclerotinia sclerotiorum* under pot condition

The study the management of the pathogen, pot experiment was conducted to evaluate the efficacy of various treatments against Sclerotinia stem rot in mustard caused by *S. sclerotiorum*. The study compared bio-agents, chemical fungicides and botanicals applied as soil treatments and foliar sprays. Results demonstrated that foliar application of Carbendazim 12% WP + Mancozeb 63% WP at 0.1% concentration was the most effective treatment, showing only 21.85% disease incidence at 60 days after sowing (DAS) and 25.13% at 90 DAS. Propiconazole 25% EC (0.1%) ranked second in effectiveness with 23.67% and 28.70% incidence at the respective time points. Amongst biological controls, soil application of *Trichoderma harzianum* (24.42% at 60 DAS and 29.17% at 90 DAS) performed better than *Trichoderma viride*(25.45% at 60 DAS and 30.15% at 90 DAS). Botanical extracts showed concentration-dependent efficacy, with 10% garlic bulb extract (25.60% and 31.50% incidence) outperforming 10% neem leaf extract (26.80% and 32.21%) at both evaluation periods. Lower concentrations (5%) of both botanicals were significantly less effective. The untreated control pots showed the highest disease incidence (55.38% at 60 DAS and 70.32% at 90 DAS), highlighting the substantial protective value of all tested treatments against this destructive pathogen.

Table 3 : Effect of botanical, chemicals and bioagents on disease incidence of Sclerotinia stem rot of mustard.

Number of Treatment	Name of Treatment	Concentration	Disease incidence (%)		Disease reduction over control (%)	
			60DAS	90DAS	60DAS	90DAS
T_1	Neem leaf extract	5%	29.30	36.10	47.09	49.08
T_2	Neem leaf extract	10%	26.80	32.21	51.60	54.19
T_3	Garlic bulb extract	5%	29.12	34.30	47.41	51.22
T_4	Garlic bulb extract	10%	25.60	31.50	53.77	55.20
T_5	Propiconazole 25% EC	0.1%	23.67	28.70	57.25	59.18
T_6	Carbendazim 12% WP + Mancozeb 63% WP	0.1%	21.85	25.13	60.54	64.26
T_7	*Trichoderma harzianum*	0.5%	24.42	29.17	55.90	58.51
T_8	*Trichoderma viride*	0.5%	25.45	30.15	53.09	56.12
T_9	Control	-	55.38	70.32	0.00	0.00
C.D			3.16	3.91	4.54	4.76
SE(m)			1.06	1.31	1.52	1.60
C.V			6.35	6.46	5.58	5.57

Conclusion

The study found that Carbendazim 12% WP + Mancozeb 63% WP (0.1%) was the most effective treatment, showing 95.2% inhibition of *Sclerotinia sclerotiorum* and the highest seed yield (23.94 g/plant). *Trichoderma harzianum* (0.5%) enhanced plant growth but was less effective in disease control than fungicides. Garlic bulb extract (10%) provided moderate suppression. An integrated approach combining chemical and biological treatments is recommended for optimal disease management and yield improvement in mustard.

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