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Research Article

MANAGEMENT OF STEM ROT OF MUSTARD INCITED *SCLEROTINIA SCLEROTIORUM* (LIB.) DE BARY

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abstract: stem rot is a potential threat to mustard and set as key disease in mustard growing area. the first symptoms appearance as elongated, water soaked spots then further it expands rapidly after 45-55 days after sowing that causes upto 81.5% losses with significantly reduction in yield. the findings revealed that carbendazim, thiophnatemethyl and propiconazole @ 0.1 percent and garlic, turmeric, eucalyptus spp., zingiber and azadirechta@ 20 percent, while, amritjal @ 15 percent were found significantly inhibited the growth and development of *s. sclerotiorum* under *in-vitro*. apart, reduced the girdled length on stem, numbers of sclerotium and surviving viability in soil under field evaluation. stem rot lowest girdled length on stem 1.76 cm, was noticed in carbendazim with 318.18 kg ha^{-1} statistically significant ($p < 0.005$) superior and at par with each other followed by *allium sativum, eucalyptus amydalin, amritjal* and *trichoderma harzianum*. it concluded that summer deep ploughing, trichoderma applied at time field preparation in incorporated with farm yard manure prepared inoculated active inoculum load of *trichoderma harzianum* then spraying of effective treatment before appearance of stem rot symptoms.

keywords: *management, sclerotinia sclerotiorum, eco-friendly, sclerotia, botanicals, biocontrol agent*

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Introduction

In Madhya Pradesh; Morena, Bhind, Gwalior, Sheopur and Datia jointly contribute >60% production of these crops. Madhya Pradesh has reached at second rank after Rajasthan in India. Stem rot {*Sclerotinia sclerotiorum*} is a potential threat to mustard cultivation. The first recorded that the occurrence of Sclerotinia blight on rapeseed and mustard has been made from India, Shaw and Ajrekar (1915) [1]. It is a soil borne in nature. Stem rot has set as a key pathogen not only in northern region of Madhya Pradesh but most mustard growing area of world [2,3].

The ascosporic release and survival sclerotia are the key stages in the life cycle *S. sclerotiorum*, Sharma *et al*. (2015) [3]. This pathogen virulence in light black to alluvial soil and water logged condition. This potential threat has become an economically important yield reducing factor especially in mustard growing areas and causing 40-80 percent losses in yield [4]. The heavy disease incidence recorded in Morena (11.52%), Bhind (13.48%) and Gwalior (6.33%) were identified a hot spot but in Sheopur (2.81%) and Datia (5.00%) were recorded fewer incidences as compare to highly incidence districts, Bharti *et al.* (2016) [5]. The aim of this study was to determine eco-friendly approaches for integrated disease management of stem rot in mustard.

Materials and Methods

The experiment was carried out on management of stem rot of mustard by applied chemicals and non-chemical approaches. All the field experiments were conducted at the experimental field of Department of Plant Pathology, College of Agriculture, Gwalior (M.P.) during *Rabi* season 2014-15 and 2015-16. The laboratory work done in the Department of Plant Pathology, College of Agriculture, Gwalior, ZDRS, Morena and College of Agriculture, Indore, (Madhya Pradesh). Gwalior is situated in Northern part of Madhya Pradesh at an elevation of 211.52 meters from mean sea level and lies between latitude and longitude 26º14' North and 78º15' East, respectively. The topography of the experimental field was plain with good irrigation facilities.

Laboratory Screening

The common available botanicals, amritjal (*Allium sativum* 1000gm, Eucalyptus sp. 250gm, *Zingiber officinalis* 250 gm, *Curcuma longa* 250 gm, Jugary (Gud)-250gm), fungicides were screened out with pure culture *S. sclerotiorum*, [Fig-1] through poisoned food technique, Nene and Thapliyal (1979) [6], however, biocontrol agents through dual culture technique, were tested under *in- vitro* before applied under field condition before appearance of stem rot symptoms. The experiments were laid out in a complete randomized design and replicated four times.

Field Evaluation

The Management of stem rot of Mustard achieved by chemicals and non-chemical rot approaches under field condition through *in-vitro* screened effective botanicals, biological agents, Amritjal and chemicals. The most effective twelve treatments with control *viz*., Amritjal @ 20%, *Allium sativum* @ 20%, *Zingiber officinalis* @ 40%, *Curcuma longa* @ 40%, *Eucalyptus* spp @ 40%, *Azadirachta indica* @ 40%, Carbendazim @ 0.1%, Propiconazole @ 0.1%, Thiophanate Methyl @ 0.1%, Thiram @ 0.2%, *T. harzianum* 4g / liter and *Trichoderma viride* @ 4g/ liter were taken for evaluation of their efficacy by foliar spray against stem rot on susceptible mustard cultivar (Rohini) and laid out in RBD with replicated thrice. Artificial inoculation through mycelium bit placement method, [Fig-2] was done after forty five days after sowing.

The first spray was done just after the appearance of the disease symptoms and subsequent two sprayings were given at an interval of 15 days. Standard agronomical practices were followed as per recommendations. Observations on disease incidence were recorded after 15 days of spraying *viz*., length of girdle, number of sclerotia per stem, size and weight per sclerotia after harvesting of the crop.

Results and Discussion

Stem rot incited by *Sclerotinia sclerotiorum* is being soil borne and sclerotia bearing pathogen. The stem rot locally known to be polio disease of mustard in the northern region of Madhya Pradesh because of the symptoms shown like polio as whole plant dwindles and die after poding stage. Earlier, it comes under minor disease out now it become potential treat in mustard cultivation.

Stem rot symptoms

It is produced symptoms on leaf and stem within very short duration 3-5 days after inoculation nearly middle age of crop. Stem rot show the symptoms as fluffy white mycelium and sclerotia are produced after the growth of mycelium and the first appearance, elongated water soaked spots then further it expand rapidly. In accordance with Meena *et al*. (2014) [7] state that severe infection, defoliation, shredding of stem, wilting and drying plants occurs infected plants with ripe earlier and stand out among green plants.

Screening of botanicals, amritjal, biocontrol agents and Fungicides against *Sclerotinia sclerotium* under in-*vitro*

The experiment data evident from [Table-1] that carbendazim 50 WP, thiophnate methyl 70 WP and propiconazole 25 EC, amritjal, *Allium sativum* were absolutely checked the mycelium growth and sclerotia formation which were found statistically (P=0.05) significantly superior over other treatments followed by mycelium growth 15.50mm, 16.33mm, 16.85mm, 22.67mm, 28.33mm and 42.50mm in Hexaconazole 5 SC, *Eucalyptus* spp, *Curcuma longa, Trichoderma harzianum, Trichoderma viride, Azadirachta indica* and *Zingiber officinalis* with their number of sclerotia, 0.75, 0.50, 1.33,0.00, 3.75,3.75 and 2.50 were noticed respectively. Similar, this work confirmed with Meena (2011) the aqueous garlic clove extract (2%) amended PDA was tested for its antifungal activities against *S. Sclerotiorum*.

Table-1 *Effects of treatments on mycelium growth and sclerotia formation of Sclerotinia sclerotiorum under in-vitro*

SN	Treatment	Mycelium growth (mm)	No. of Sclerotia / plate
1	*Trichoderma viride*	28.33	3.75
2	*Trichoderma harzianum*	22.67	0.00
3	*Allium sativum*	0.00	0.00
4	*Eucalyptus spp*	16.33	0.50
5	*Curcuma longa*	16.85	1.33
6	*Azadirachta indica*	42.50	3.75
7	*Zingiber officinalis*	44.75	2.50
8	Amrit jal	0.00	0.00
9	Carbendazim 50 WP	0.00	0.00
10	Thiophnate methyl 70 WP	0.00	0.00
11	Propiconazole 25 EC	0.00	0.00
12	Hexaconazole 5 SC	16.50	0.75
13	Control	85.67	5.25
	Se(M)	0.434	0.381
	CD	0.781	0.684

Basak *et al*. (2002) [8] reported that cow urine had a very effective role in suppression of mycelial growth. No mycelial growth was observed up to 4 days in treated sclerotia with cow urine. After 5 days only 0.9 mm mycelial growth was measured in treated sclerotia, while in case of untreated sclerotia the growth was 42.6 mm, noticed by Murugan *et al*. (2012) [9]. Mehta *et al*. (2012) [10] evaluate the efficacy of various antagonists against *S. sclerotiorum*, isolates of *Trichoderma harzianum* - 3 and *T. harzianum* - 4 were significantly better and most potent in reducing the growth of *S. sclerotiorum*. Earlier, biocontrol agents tested antagonists *T. harzianum* - 4, *T. harzianum* - 3, and T. virens reduced sclerotia formation, Yadav *et al*. (2011) [11]. Shivpuri and Gupta (2001) [12] they tested six fungicides against *S. sclerotiorum* and reported carbendazim, thiophanate-methyl and phenyl pyrrole completely inhibited the growth of the pathogen at all concentrations, thereby resulting in the lowest number of sclerotia, findings confirmed by Tripathi and Tripathi (2010) [13].

Management of stem rot under field condition

In-vitro tested selected effective twelve treatments with control were evaluated against stem rot under field condition with the artificial inoculation through mycelium bit placement method by newly young growth at 5 days old mycelium. It is evident from the [Table-2] that Carbendazim, Thiophnate methyl and Propiconazole from fungicides, *Allium sativum*, Eucalyptus from botanicals and *Trichoderma harzianum* from biocontrol agents were found effective against stem rot of Mustard. None of the treatment remained absolutely free from stem rot infection.

The overall average girdled length of infection minimum 1.76 cm on stem was observed in carbendazim which significantly superior over other twelve treatments. This was followed by 2.01cm, 2.12 cm, 2.95 cm, 3.01 cm, 3.15 cm and 3.57 cm girdled length on stem in thiophnate methyl, propiconazole, *Allium sativum,* Amritjal*, Trichoderma harzianum and Eucalyptus amydalin* were recorded, while, the maximum infection girdled length (18.93 cm) on stem was noticed in *Azadirachta indica* followed by 16.53 cm, 15.28 cm, 13.76 cm and 11.69 cm in hexaconazole, *Trichoderma viride, Zingiber officinale* and *Curcuma longa* was recorded, respectively. The appearance and griddled length on stem affected the plant yield significantly. Yadav *et al*. (2011) reported that the tested fungicides and garlic extract significantly reduced sclerotinia disease incidence. Among the fungicides, carbendazim was the best, reducing the disease incidence by 75.40 and 72.63% in 2003-04; respectively. The present findings are agreement with Meena *et al*. (2013) [14] and Mehta *et al*. (2011) [15].

The sclerotia development inside stem pith was absolutely checked by carbendazim, thiophnate methyl, propiconazole, *Allium sativum* and Amritjal. However, minimum 1.10 sclerotia formed in Curcuma longa followed by 1.40, 1.50 and 1.74 in *Zingiber officinale, Trichoderma viride* and Hexaconazole were recorded, while, the maximum 6.90 sclerotia formed in *Azadirachta indica*, [Table-3]. The sclerotia formation and development was absolutely checked by carbendazim, thiophnate methyl, propiconazole, *Allium sativum*, Amritjal, *Eucalyptus amydalin* and *Trichoderma harzianum* with statistically significantly superior and at par with each other. Earlier researcher, Aujla *et al*. (2002) [16] reported and confirmed that the treatment of sclerotia with biological agents like *Trichoderma harzianum* and *T. viride* resulted in the loss of their viability and apothecial formation after 2 months of treatment.

The sclerotial length in different treatments in the ranged of 3.07 – 4.60 mm was recorded. The smallest sclerotia formed in *Curcuma longa* and biggest in *Azadirachta indica* over the control (18.27 mm) was noticed. The weights of sclerotia per plant across the treatments in the range of 16.93-28.67 mg were noticed. The gradual reduction in variability of sclerotic germination (germination percent) of *S. sclerotiorum* we observed with the increase in soil depth and duration of burial both under screened home and field condition, Rakesh *et al*. (2016) [17] similar study confirmed by Cosic *et al*. (2014) [18].

The stem rot was noticed at near flower or poding stage (Early stage of Plant), then very low yield wad harvested because girdled length below 4 cm was observed, besides, the girdled length more than4 cm on stem was observed yield significant gradually less harvested.

The plant was infected at early stage near 25-30 days old that completely dead before flowering and poding. The maximum yield 318.18 kg ha^{-1} in carbendazim with little infection observed on stem but it has no further rapid spread followed by 311.93 kg ha^{-1} and 311.47 kg ha^{-1} in thiophnate methyl and propiconazole which statistically significant superior over other treatment and at par with each other, while, minimum yield 60.90 kg ha^{-1} in *A. indica* compare with control 57.85 kg ha^{-1} followed by 66.20 kg ha^{-1} , 72.12 kg ha^{-1} and 76.97 kg ha^{-1} in hexaconazole, *Z. officinalis* and *T. viride* were recorded. In accordance with Meena (2011) studied that foliar spray by garlic bulb extract increased the seed yield significantly as compare to control.

Table-2 *Effect of in-vitro selected treatments on girdle length (cm) of inoculated stem*

Treatment	15 DAI			30 DAI			45 DAI			60 DAI			Overall average mean
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	
Trichoderma viride	4.40	4.27	4.34	15.47	15.53	15.50	18.07	17.93	18.00	23.27	23.33	23.30	15.28
T. harzianum	1.07	1.13	1.10	3.53	3.93	3.73	3.80	3.93	3.87	3.87	3.93	3.90	3.15
Allium sativum	1.07	0.93	1.00	3.47	3.67	3.57	3.53	3.67	3.60	3.60	3.67	3.64	2.95
Eucalyptus spp	2.00	1.93	1.97	3.93	4.13	4.03	4.07	4.13	4.10	4.20	4.13	4.17	3.57
Curcuma longa	2.47	2.40	2.44	9.67	9.87	9.77	15.93	16.07	16.00	18.53	18.60	18.57	11.69
Azadirachta indica	5.07	5.33	5.20	18.73	18.13	18.43	22.67	22.07	22.37	29.60	29.80	29.70	18.93
Zingiber officinalis	2.93	3.07	3.00	11.73	11.93	11.83	17.53	17.60	17.57	22.60	22.67	22.64	13.76
Amrit jal	1.00	1.07	1.04	3.47	3.73	3.60	3.67	3.73	3.70	3.67	3.73	3.70	3.01
Carbendazim	0.60	0.73	0.67	1.67	2.27	1.97	2.07	2.27	2.17	2.20	2.27	2.24	1.76
Thiophnate methyl	0.67	0.93	0.80	2.00	2.53	2.27	2.40	2.53	2.47	2.47	2.53	2.50	2.01
Propiconazole	0.73	0.87	0.80	2.20	2.67	2.44	2.53	2.67	2.60	2.60	2.67	2.64	2.12
Hexaconazole	4.93	5.00	4.97	17.67	11.33	14.50	18.47	18.33	18.40	28.27	28.20	28.24	16.53
Control	8.87	9.13	9.00	19.60	19.07	19.34	25.00	24.33	24.67	32.00	32.07	32.04	21.26
SE (m) ±	0.26	0.21	0.23	0.44	0.42	0.42	0.83	0.79	0.80	0.63	0.63	0.63	0.53
CD 5%	0.78	0.63	0.68	1.30	1.24	1.24	2.44	2.32	2.34	1.86	1.85	1.85	1.55

Table-3 *Effect of in-vitro selected treatments on Sclerotia of stem rot*

Treatment	Yield kg/ ha			Overall average girdle length (cm)	Sclerotia per plant stem			Sclerotia Length (mm)			Weight per sclerotia (mg)		
	2015	2016	Mean		2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
Trichoderma viride	73.657	71.483	76.97	15.28	1.47	1.53	1.5	4.53	4.67	4.6	23.53	30.53	27.03
T. harzianum	183.24	189.06	186.88	3.15	0	0	0	0	0	0	0	0	0
Allium sativum	199.01	200.16	201.59	2.95	0	0	0	0	0	0	0	0	0
Eucalyptus spp	178.39	182.67	187.71	3.57	0	0	0	0	0	0	0	0	0
Curcuma longa	98.134	96.755	98.78	11.69	1.07	1.13	1.1	3.07	3.07	3.07	15.13	18.73	16.93
Azadirachta indica	60.382	63.403	60.90	18.93	7.07	6.73	6.9	4.93	4.07	4.5	23.87	28.47	26.17
Zingiber officinalis	72.186	69.817	72.12	13.76	1.33	1.47	1.4	3.6	2.67	3.14	22	26.07	24.04
Amrit jal	185.88	189.37	190.45	3.01	0	0	0	0	0	0	0	0	0
Carbendazim	313.86	318.19	318.18	1.76	0	0	0	0	0	0	0	0	0
Thiophnate methyl	307.52	317.65	311.93	2.01	0	0	0	0	0	0	0	0	0
Propiconazole	309.03	312.81	311.47	2.12	0	0	0	0	0	0	0	0	0
Hexaconazole	67.307	65.07	66.20	16.53	1.67	1.8	1.74	4.47	4.53	4.5	27.67	29.67	28.67
Control	59.223	55.903	57.85	21.26	18.2	18.33	18.27	6.8	5.6	6.2	28.13	29.6	28.87
SE (m) ±	2.39	2.47	1.44	0.53	0.85	0.83	0.84	0.27	0.27	0.25	1.36	1.68	0.8
CD 5%	6.98	7.22	4.22	1.55	2.47	2.42	2.44	0.79	0.77	0.72	3.96	3.41	2.33

Conclusion

The management is enormous challenges faced by plant pathologists and farmers. It is difficult, inconsistent and uneconomical due to the availability of wide host range and long duration to survive of resting sclerotia. In the field evaluation among all the treatments none of treatment gave complete freedom from the disease infection, however, carbendazim was found most effective followed by thiophnate methyl and propiconazole.

Application of research

In the non- chemicals, Allium sativum was managed effectively of the disease followed by *Trichoderma harzianum*, amritjal against the stem rot of mustard.

Research Category: Plant Pathology

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Study area / Sample Collection

Department of Plant Pathology, College of Agriculture, Gwalior

Cultivar / Variety / Breed name: Mustard

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