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Short communication

Efficacy of fungicides for control of white mold (*Sclerotinia sclerotiorum* Lib.) de Bary in lima bean

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ABSTRACT

White mold of lima bean (*Phaseolous lunatus)* caused by *Sclerotinia sclerotiorum* is a major disease in India. Isolates of the pathogen from different region of Uttar Pradesh were assayed both *in vitro* and in the greenhouse (*in vivo*) for their sensitivity to eight commercially available fungicides, viz., dithiocarbamic acid, carbendazim, ziram, phenylthiourea, carboxin + dithiocarbamic acid, difenoconazole, hydrogen sulphide, and mancozeb. Phenylthiourea and difenoconazole were found to be most effective and these inhibited radial growth of the test organism a level of to 71.5% and 70.5%, respectively. These two fungicides were also found as most promising in controlling the disease under greenhouse conditions, reducing disease severity to 0.14% and 0.22%, respectively compared to the control where it was 18.9%.

Keywords: *Sclerotinia sclerotiorum,* white mold, *Phaseolous lunatus,* lima bean, fungicides

Sclerotinia sclerotiorum (Lib.) de Bary [Syn. *S. libertiana* Fuckel: *Whetzelinia sclerotiorum* (Lib.) Korf and Dunont], commonly called the white mold, is among the most non-specific, omnivorous and successful plant pathogens. Plants susceptible to this pathogen belong to 64 families, 225 genera and 361 species (Purdy, 1979) and the pathogen has an ability to survive in soil for long periods as sclerotia (Purdy, 1979; Willetts and Wong, 1980). The pathogen attacks nearly all kinds of succulent plants including flowers, shrubs weeds and almost all vegetables (Chupp and Sherf, 1960).

Phaseolous lunatus (lima bean) is one of the important vegetable crops. Its fresh seeds can be used as vegetable and dry seed as pulse for human consumption and as fodder in general, especially for mulch cattle. The crop suffers due to infection of *Sclerotinia sclerotiorum* (Lib.) de Bary which causes white mold. The pods can become infected while on the plant and at post-harvest. To combat the disease, soil solarization (Ferraz, 2001), crop rotation and chemical control (Kurozawa and Pavan, 1997) are employed. Due to lack of adequate levels of host resistance, many fungicides have been employed to control sclerotinia disease (Steadman, 1979; Bardin and Huang, 2001). Use of fungicides to control *S. sclerotiorum* has been evaluated in snap bean (*Phaseolus vulgaris* L.). However, control has been inconsistent (Hunter *et al*, 1978; Steadman, 1979) primarily due to difficulty in achieving good coverage with the fungicide and timing of application in relation to ascospore release. Fungicides have been used successfully on a commercial scale for controlling the disease on soybean, dry bean, oilseed rape and several vegetables (Bailey *et al*, 2001; Budge and Whipps, 2001; Del Rio *et al*, 2004), but, adequate information on the efficacy of various fungicides and their judicious usage is lacking in controlling white mold on *P. lunatus* (Gossen *et al*, 2001).

Therefore, the present investigation describes the efficacy of eight commercially available fungicides [which were tested both *in vitro* and under greenhouse (*in vivo*) condition] against the pathogen causing white mold in *P. lunatus.*

Maintenance of *Sclerotinia sclerotiorum* isolates

Five isolates of *S. sclerotiorum* used in the present study were collected from infected *P. lunatus* plants growing in five different districts of Uttar Pradesh namely Faizabad, Akbarpur, Gonda, Basti and Lucknow (Table 1). The pathogen was isolated on PDA plates and the isolates were further purified by growing *sclerotia* singly from each colony on Potato Dextrose Agar (PDA) slants.

Table 1. Colony characteristics of various isolates of *Sclerotinia sclerotiorum* collected during 2007 on host *Phaseolus lunatus*

Isolate(s)	Place of collection	Colony morphology	Growth rate (mm per day)	No. of sclerotia per plate	Period (days) of sclerotium formation	Pattern of sclerotium formation
Ss 1	Faizabad	Fluffy	40	31	Days	Scattered
Ss 2	Akbarpur	Fluffy	42	19	Days	Near rim
Ss 3	Gonda	Fluffy	39	25	Days	Near rim
Ss 4	Basti	Compact	48	25	Days	Scattered
Ss 5	Faizabad	Compact	35	12	Days	Scattered

Table 2. Nature of fungicides used and their active chemical

S. No.	Common name	IUPAC name	Active chemical	Nature
1	Thiram	Tetramethyl thiuram disulphides	Dithiocarbamic acid	Contact
2	Bavistin	Methyl benzimidazol-2-ylcarbamate	Carbendazim	Systemic
3	Cuman	Zinc dimethyl dithiocarbamate	Ziram	Contact
4	Topsin-M	Methyl-ethyl-thiophanate	Phenylthiourea	Systemic
5	Vitavax	5,6-Dihydro-2-methyl-1,4-oxathi-ine-3-carboxanilide	Carboxin + Dithiocarbamic acid	Systemic + Contact
6	Score	1-(2-[4-(4-chlorophenoxy)-2-chlorphenyl]-4-methyl-1, 3-dioxolan-2-yl methyl]-1 H-1,2,4-triazole	Difenoconazole	Systemic
7	Sulfex	Elemental sulfur	Hydrogen sulphide	Contact
8	Indofil- M 45	Manganese ethylene (dithiocarbamate) (polymeric) complex with zinc salt	Mancozeb	Contact

Table 3. Effect of fungicides on percentage inhibition of radial growth of *S. sclerotiorum* (*in vitro*)

S. sclerotiorumisolates	Inhibition of radial growth (%) by fungicides							
	Dithiocarbamic acid	Carbendazim	Ziram	Phenylthiourea	Carboxin + Dithiocarbamic acid	Difenoconazole	Hydrogen sulphide	Mancozeb
Ss 1	27.8	34.5	24.6	70.2	34.8	67.9	31.5	42.0
Ss 2	34.7	32.5	26.5	71.5	36.5	66.0	30.6	41.4
Ss 3	23.4	32.5	22.8	69.6	33.6	68.4	28.6	38.9
Ss 4	27.9	33.4	22.8	69.9	34.0	70.5	28.4	39.9
Ss 5	32.8	29.8	22.6	69.5	35.3	69.8	32.4	38.9
CD (*P>0.05)*	0.55	1.02	0.28	1.18	0.88	1.25	0.64	1.04

Colony characteristics

Radial growth (mm), morphology and number of sclerotia per plate were evaluated in Petri dishes on PDA. At least three PDA plates were inoculated with 5mm dia. mycelial discs taken from the margin of actively growing five day old colonies in each plate. Inoculated plates were then incubated at 25±2°C. Colony diameter was measured every day until fifth day. Number of sclerotia per plate was estimated at 20-25 days of incubation. Data from replicated plates were averaged. Colony morphology was also observed at 10 days of incubation.

In vitro experiment

Eight fungicides, viz., dithiocarbamic acid, carbendazim, ziram, phenylthiourea, carboxin + dithiocarbamic acid, difenoconazole, hydrogen sulphide and mancozeb (Table 2) were evaluated for control of white mold fungus on PDA and on seedlings of *P. lunatus* as per Bhaktavatsalam *et al* (1978).

Greenhouse experiment

Eight commercially available fungicides were evaluated for control of *S. sclerotiorum* on *P. lunatus* as per Mueller *et al* (2002).

Colony characteristics: Data on colony characteristics, growth rate, number of sclerotia per plate and period taken for sclerotia formation in five isolates of *S. sclerotiorum* collected from different location is presented in Table 1. Of the five, three isolates collected from Faizabad, Akbarpur and Gonda formed fluffy colonies whereas, isolates from Basti and Lucknow had compact colonies. The isolate collected from Basti showed maximum growth rate, *i.e.*, 48mm per day, and the isolate collected from Lucknow showed minimum growth of 35mm per day. A maximum of 42 sclerotia per plate were formed in the isolate collected from Akbarpur, whereas only 19 sclerotia per plate were formed in the Lucknow isolate. All the isolates took uniformly seven days for sclerotia formation.

Table 4. Evaluation of fungicide against *S. sclerotiorum* under green house condition (*in vivo*)

Fungicidesname	Rate (kg a.i./ha)	Disease severity in Seedlings
Control (Untreated)	-	18.90
Dithiocarbamic acid	0.52	2.60
Carbendazim	0.65	1.90
Ziram	0.66	2.20
Phenylthiourea	0.72	0.14
Carboxin + Dithiocarbamic acid	0.72	1.30
Difenoconazole	1.16	0.22
Hydrogen sulphide	0.86	1.10
Mancozeb	1.22	0.88
CD (*P>0.05*)	0.58	0.84

***In vitro* experiments:** It is clear from data presented in Table 3 that all the chemical pesticides tested were effective against the test organism in comparison to control. Extent of mycelial growth in *S. sclerotiorum* in response to each fungicide varied considerably. Phenylthiourea was found most effective in reducing mycelial growth by 69.5% to 71.5%, followed by difenoconazole where inhibition was recorded 66% to 71.5%. Mancozeb, carboxin + dithiocarbamic acid and carbendazim exhibited intermediate level of inhibition, whereas hydrogen sulphide, ziram and dithiocarbamic acid showed lowest effectiveness in inhibiting mycelial growth. *In vitro* studies have earlier been used to identify specific fungicide and rate of fungicidal activity against *S. sclerotiorum* (Hawthorne and Jarvis, 1973). Phenylthiourea has been proved to be effective against *Fusarium oxysporum* and *Rhizoctonia solani* (Iqbal *et al*, 1996) and aganist *Ascochyta. lentis* (Rauf *et al*, 1996).

Greenhouse experiments: A significant (*P<0.05*) effect among the eight fungicides tested was observed on disease severity. Plants not sprayed with fungicide had expanded foliar lesions that caused defoliation. Fungal colonized stems and some plants were dead. Phenylthiourea and difenoconazole were most effective in controlling the disease under greenhouse, exhibiting 0.14% and 0.22% disease severity, respectively (Table 4). These results are in accordance with earlier findings showing that spraying the whole plant with effective fungicides provides excellent control of *S. sclerotiorum* (Hunter *et al*, 1978).

Thus the present study revealed that topsin–M was found to be most effective, both in *in vitro* and greenhouse conditions, against *Sclerotinia* rot in lima bary. In Brinjal (Iqbal *et al*, 2003). Muller *et al*, (2002) reported that plants treated with benomyl, thiophanate methyl and vinclozolin expressed no symptoms or signs of *Sclerotinia* stem rot in soybean.

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