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COLLAR AND STEM ROT PATHOGEN- *SCLEROTIUM ROLFSII* : A REVIEW

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ABSTRACT

Sclerotium rolfsii is a soil-borne saprophytic fungus responsible for various diseases such as collar-rot, sclerotium wilt, stem-rot, charcoal rot, seedling blight, damping-off, foot-rot, stem blight and root-rot in over 500 plant species, including but not limited to tomato, chili, sunflower, cucumber, eggplant, soybean, maize, groundnut, beans, watermelon, etc.It is a versatile organism which persists in subtropical regions around the world and present in almost all the states in our country. The initial symptoms produced by this pathogen include pre and post emergence damping off of seedlings. Whereas in mature plants, infected stems develop dark brown lesions and as the disease progresses sclerotial bodies are produced in abundant number at the base of the plants and soil which produces wilting symptoms in plants and ultimately results in death of the infected plants. It is a most dreaded plant pathogen which is hard to control by any single means. *S. rolfsii* may be controlled through various fungal antagonists such as *Trichoderma harzianum*, *T. viride*, *T. asperellum* and bacterial antagonists such as *Bacillus subtilis*, *Pseudomonas fluorescens*, etc. Mechanism of action of antagonists against plant pathogens includes competition, hyper parasitism, antibiosis, etc. Apart from biocontrol agents, several chemicals were also used for the management of diseases caused by *Sclerotium rolfsii*, which include avatar (hexaconazole 4% + Zineb 50%), tegula (tebuconazole), ridomil gold (metalaxyl + mancozeb), thiophanate methyl and mancozeb.

Key words : *Sclerotium rolfsii*, Biological control, *Trichoderma*, *Bacillus*, Fungicides.

Introduction

Soil-borne plant pathogens pose significant threats to crop production, impacting the plant at all stages of crop growth. Some of these pathogens are particularly formidable because they can persist in the soil for extended periods. Consequently, there is a growing imperative to prioritize management of soil-borne pathogensin crop cultivation. One such pathogen, *Sclerotium rolfsii*, has been gaining prominence in recent times, partly because of climate change. The pathogen causes different types of diseases such as collar rot, *sclerotium* wilt, stem rot, charcoal rot, seedling blight, damping-off, foot-rot, stem blight and rootrot in many economically important agriculture and horticulture crops.

Sclerotium rolfsii is a versatile organism that persists in soil as a saprotroph, which is capable of both attacking living plants and functioning as a facultative parasite. This omni pathogenic organism is globally distributed and has the capacity to infect over 500 plant species. The pathogen survives during the unfavourable conditions for many years in the soil in the form of sclerotial bodies (Vaniya *et al*., 2022).

Collar rot and stem rot are very important diseases caused by *Sclerotium rolfsii*. Under favourable environmental conditions such as adequate rainfall and soil temperatures ranging from 25 to 30°C, this disease can lead to mortality rates of 55-95% in various crop seedlings (Sharma and Ghosh, 2017).Collar rot (*Sclerotium rolfsii*) requires warm climate, high moisture and high temperature (Singh *et al*., 2023). The illness typically manifests about two weeks after planting. Younger seedlings show evident decay around the collar area, leading to their collapse, while older seedlings tend to become yellow and may wither without collapsing.

Occurrence and distribution

Sclerotium rolfsii is a widely distributed soil-borne plant pathogenic fungus found in tropical and subtropical regions around the world (Elasmi *et al.*, 2015; Patra *et al.*, 2023). In India, *Sclerotium rolfsii* is extensively distributed across almost all states, with particular prevalence in regions such as Gujarat, Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh. Pathogen infestation is frequently observed in irrigated crops cultivated during the post-rainy and summer seasons in India (Kumar *et al.*, 2013). Apart from infecting crops, *Sclerotium rolfsii* also reported to induce the production of toxic secondary metabolites in the affected crops (Cavalcanti *et al.*, 2018).

The Pathogen

The pathogen was first time reported by Rolfs in 1892 on tomato causing blight. The pathogen was renamed as *Sclerotium rolfsii* in 1911. In India, Shaw and Ajrekar (1915) originally isolated the fungus from decayed potatoes, initially identifying it as *Rhizoctonia* spp. genus. Subsequently, Ramakrishnan (1930) confirmed that the fungus in question was indeed *Sclerotium rolfsii*. The fungus exhibits a white, cottony mycelial growth when cultured on a potato dextrose agar medium. The appearance of the colony can range from dense and compact to fluffy. Initially, it forms white-colored sclerotia, but as they mature, their color transitions from white to off-white, light brown, and eventually dark brown, as documented by Meena *et al*. (2023)

Epidemiology

The disease can result in significant yield losses when environmental conditions, such as soil temperature and humidity, are conducive to fungal development, and when the disease incidence is high (Sen *et al*., 2023). Tarafdar *et al*. (2018) stated that population of *Sclerotium rolfsii* was maximum, when the moisture content of soil ranged between 30 to 50%. The fungus demonstrates a quick production of mycelium and sclerotia, particularly thriving in conditions of elevated moisture and high temperatures, typically within the range of 30 to 35°C (Kumari and Ghatak, 2018). Furthermore, infection and the spread of fungal mycelium within and between plants are promoted by factors such as high soil moisture, dense plant populations, and frequent irrigation (Sconyers *et al*., 2005; Sirvidya *et al*., 2022).

Symptomatology

The first symptoms observed were pre and post emergence damping off on seedlings which were infected with the pathogen *Sclerotium rolfsii* (Agarwal and Kotasthane, 1971). On the matured plants, infected stems develop dark brown lesions at the collar region, leading to wilting and eventual desiccation of the plants. As the infection progresses, brownish sclerotial bodies, resembling mustard seeds, emerge in the later stages on both the root and collar regions of the afflicted plants (Kulkarni *et al*., 1995). The symptoms of collar rot infected plants include yellowing of foliage and ultimately drying up before succumbing to the disease. Additionally, the affected plant tends to scatter throughout the entire field, serving as a clear indicator of collar rot disease (Reddi *et al*., 2014). During the initial stages of infection on host plants, darkening and decay of the lower stem area occurs which eventually resulted in the complete drying of the entire plant. Presence of white powdery mycelial growth and sclerotial bodies on the lower portion of the infected plant and in the soil surrounding the stem were observed (Brunda, 2018; Sindhu, 2019; Vivekanand, 2020).

Morphological characters

Manjappa (1979) isolated and studied cultural and morphology in the cultures of *Sclerotium rolfsii* isolated from different crops and reported thatthere were significant variations in terms of growth rate and sclerotia in both liquid and solid media. Similarly, Shantha Lakshmi Prasad (2012) isolated and studied a total of 22 isolates of *Sclerotium rolfsii* and reported that they show significant variation in their growth parameters and colony morphology such as growth rate, color, number and size of sclerotia, etc. Kumar *et al*. (2014) observed that all the isolated of *Sclerotium rolfsii* displayed a range of growth patterns, from dispersed growth all over the petri plate to a more aggregated fashion. The appearance of mycelium of these isolates varied from loose to dense cottony, with some exhibiting sparse or fluffy mycelium. In a very similar study, Akram et al. (2015) observed silky-white color mycelia with fluffy or compact growth on PDA and MEA. Paul *et al*. (2017) isolated 36 cultures from infected *Ipomea batatas* and identified them based on their morphological characters as cultures of *Sclerotium rolfsii*. Manu *et al*. (2018) reported that the cultures of *Sclerotium rolfsii* reddish brown sclerotia which were 573 in number. Nugroho et al. (2019) cultured the isolate of *Sclerotium rolfsii* on PDA and found that the diameter of the hypha ranged between 4 – 9 µm and presence of clamp connections were confirmed.

Management of *Sclerotium rolfsii*

Biological control

Among the soil microorganisms, there are forms that inhibit the growth of other microbes; these are called

Photo 1 : Collar rot of brinjal.

Photo 2 : *Sclerotium rolfsii* infection in common bean.

Photo 3 : *Sclerotium rolfsii* infection in pepper.

Photo 4 : *Sclerotium rolfsii* stem rot in green gram.

antagonists. Employing antagonists for the biological management of this disease is an environmentally sustainable method, offering a superior alternative to the utilization of chemicals (Moranf *et al.*, 2012).

Trichoderma spp. as biocontrol antagonist

Trichoderma spp. has been employed as biocontrol agents against soil-borne plant-pathogenic fungi since so many years (Kucuk and Kivank, 2003). *Trichoderma* spp. employs various strategies for protection of plants against plant pathogens which include mycoparasitism (Harman *et al.*, 2004), competition, antibiosis, parasitism, and the induction of systemic resistance (Hoitink *et al.*, 2006). Earlier *Trichoderma* spp. were employed for the management of diseases caused by *Sclerotium rolfsii* in beans, tomato, peanut, sugar beet, cucumber and soybean (Naeimi *et al.*, 2010; Kotasthane *et al.*, 2015). *Trichoderma* spp. has the ability to mobilize and absorb nutrients from the soil, making them unavailable for numerous other soil microorganisms thus competing with them (Benitz *et al.*, 2004). Mycoparasitism is a process initiated in response to the presence of phytopathogenic fungi. It involves the release of hydrolytic enzymes, primarily chitinases, glucanases, and proteases, which enable *Trichoderma* spp. hyphae to inhibit the growth of pathogenic organisms (Reithner *et al.*, 2011; Rasu *et al.*, 2012). The chitinases produced by *Trichoderma* spp. degrade the chitin found in the cell walls of *Sclerotium rolfsii*, facilitating the penetration of *Trichoderma* spp. hyphae into the mycelium of *Sclerotium rolfsii*. During interaction in hyper-parasitism, it was found through light microscopy studies that the mycelium of *Trichoderma* spp. coil around the mycelia of *Sclerotium rolfsii* and degenerate them (Hassan *et al.*, 2013). Singh *et al.* (2017) documented that the application of *Trichoderma harzianum* through seed treatment effectively managed collar rot disease in chickpea, which is caused by *Sclerotium rolfsii*. Similar results were reported earlier in which Sarita *et al.* (2018) observed that incidence and severity of stem rot of groundnut caused by *Sclerotium rolfsii* was significantly reduced when *Trichoderma harzianum* and *T. viride* were applied as seed treatments.

Bacillus spp. as biocontrol antagonists

Bacillus species are among the most prominent bacterial antagonists found to colonize plant roots and soil. Bacillus species protect plants against pathogens by direct antagonistic interactions between the biocontrol agent and the pathogen, as well as, by induction of host resistance. *Bacillus* spp. produce structurally diverse variety of antibiotics, siderophores (iron chelators), phytohormones andalso soluble inorganic minerals in the soil (Liu *et al*., 2008; Viruel *et al*., 2011). The majority of *B. subtilis* strains possess the capability to produce multiple antimicrobial compounds. Furthermore, surfactin and bacillomycin work in synergy to control pathogens, with their biosynthetic pathways being interconnected to some extent, as demonstrated by Luo *et al*. (2015). Surfactins produced by *Bacillus* spp. disrupt cell membranes by integrating into lipid layers of various plant pathogens (Blake *et al*., 2021).

Effect of chemicals in the management of *Sclerotium rolfsii*

Under field conditions, the fungicides hexaconazole, propiconazole, difenoconazole, avatar (hexaconazole 4% + zineb 68%), nativo (tebuconazole 50%+ trifloxystrobin 25%), and vitavax powder (thiram 37.5%+carboxin 37.5%), have been reported to inhibit *Sclerotium rolfsii*, (Manu *et al*., 2012). Similarly, tegula (tebuconazole), ridomil gold (metalaxyl+mancozeb), thiophanate methyl, and mancozeb, exhibited significant inhibition of the radial growth of *S. rolfsii in vitro*. Additionally, these two fungicides, thiophanate methyl and mancozeb, effectively controlled the disease incidence caused by *Sclerotium rolfsii* under field conditions, thereby contributing to the management of collar rot disease in chickpea (Khan and Javaid, 2015). Fluazinam has demonstrated strong antifungal activity against *Sclerotium rolfsii*, the pathogen responsible for stem rot (Wang *et al*., 2015). Some of the soil fumigants like methyl bromide, methane sodium and chloropicrin were reported to inhibit the growth of *Sclerotium rolfsii* in the soil (Puri, 2016). Ahsan *et al*. (2018) assessed the efficacy of five fungicides, namely Hexaconazole, Carbendazim, Carboxin, Propiconazole and Thiophanate Methyl, when applied at a rate of 2.0 g/kg of seeds as seed treatment of chickpea seeds against collar rot disease and found that all the fungicides exhibited significant effectiveness, with Carboxin being particularly noteworthy as it inhibited collar rot disease in chickpea by 66.70%. Siddique *et al*. (2018) evaluated the efficacy of fungicides against foot and root rot caused by *Sclerotium rolfsii* and recorded very low disease severity and incidence (7.10%), when treated with Bavistin 50 WP followed by topgan 50 WP (84.27%).

Conclusion

Numerous strategies were employed for controlling *Sclerotium rolfsii* by various researchers. These approaches include biological control, cultural control methods, and chemical control measures but little to no success were obtained in controlling the pathogen by applying any single methods. So, an innovative approach has to be developed for the control of this pathogen by integrating different components which should also be cost effective and environmentally sound.

Conflict of interest

There is no potential conflict of interest declared by any authors.

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