Volume 04, Issue 04, 2026
ISSN: 2584-153X
Article ID: G-26-0402

SCLEROTIUM ROLFSII - A MAJOR THREAT TO SUSTAINABLE CROP PRODUCTION

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Abstract

Sclerotium rolfsii is a highly destructive soil-borne fungal pathogen with a remarkably wide host range, affecting over 500 plant species including economically important crops such as tomato, groundnut, soybean, and chilli. It is responsible for diseases like southern blight, stem rot, and collar rot, particularly in tropical and subtropical regions. The pathogen survives in soil through resilient sclerotia and infects plants at or near the soil line, leading to rapid disease development characterized by wilting, yellowing, and tissue decay. Its infection process is driven by the production of oxalic acid and cell wall degrading enzymes, which facilitate host tissue colonization and nutrient acquisition. The disease cycle involves both survival through sclerotia and, under favourable conditions, sexual reproduction. Due to its persistence and adaptability, management of *S. rolfsii* remains challenging, and sole dependence on chemical fungicides is often ineffective and environmentally unsustainable. Recent research highlights biological control as a promising and eco-friendly alternative. Beneficial microorganisms, particularly species of *Trichoderma*, *Bacillus*, and *Pseudomonas*, suppress the pathogen through mechanisms such as mycoparasitism, antibiosis, competition, and induction of plant defense responses. These agents not only reduce disease incidence but also enhance plant growth and productivity in crops like groundnut, tomato, and chickpea. Emerging approaches, including endophytic microbes, further expand the scope for sustainable disease management. Overall, understanding the biology, infection mechanisms, and management strategies of *Sclerotium rolfsii* is crucial for developing integrated and sustainable approaches to protect crops and ensure agricultural productivity.

Key words: *Bacillus*, Bio control, Collar rot, *Sclerotium rolfsii,* Stem rot, *Trichoderma*

Introduction

Sclerotium rolfsii is one of the most destructive soil-borne fungi affecting agriculture worldwide. It attacks a wide range of crops more than 500 plant species including important ones like tomato, groundnut, soybean, and pepper. Farmers often recognize its damage through diseases such as southern blight, stem rot, collar rot, and white mould, especially in warm tropical and subtropical regions.

This pathogen survives in the soil for long periods by forming tough, seed-like structures called sclerotia. Once conditions become favourable, it infects plants near the soil surface, causing symptoms like yellowing, wilting, soft rotting of tissues, and ultimately plant death.

The fungus spreads quickly by producing substances like oxalic acid and enzymes that break down plant tissues, helping it invade and feed on the host (Paparu *et al.,* 2020).

Managing this pathogen is challenging because it persists in soil and adapts easily. Relying only on chemical fungicides is often ineffective and can harm the environment. As a result, scientists are increasingly focusing on eco-friendly approaches. Beneficial microorganisms such as *Trichoderma*, *Pseudomonas*, and *Bacillus* have shown promising results in controlling the disease by attacking the pathogen, competing for nutrients, and boosting plant immunity (Boruah and Dutta, 2021).

With growing interest in sustainable agriculture, newer strategies like using endophytic microbes and microbial mixtures are gaining attention. Understanding the biology and management of *Sclerotium rolfsii* is essential for developing effective and environmentally safe solutions to protect crops.

Taxonomy Classification

The fungus *Sclerotium rolfsii* has an interesting history of discovery and classification. It was first described in 1911 by the Italian mycologist Pier Andrea Saccardo, based on samples sent by Peter Henry Rolfs, who had earlier linked the fungus to tomato blight in Florida in 1892. The samples contained only fungal threads (hyphae) and survival structures (sclerotia), so Saccardo placed it in a group called *Sclerotium* and named it *Sclerotium rolfsii*. However, scientists later realized that it did not truly belong to this group (Aycock, 1966; Farr *et al*., 1989).

In 1932, Mario Curzi identified its spore-producing (sexual) stage and classified it under *Corticium*. With further advances in fungal taxonomy, the fungus was finally reclassified into a more accurate group, *Athelia*, in 1978.

Symptomology

A *Sclerotium rolfsii* mainly attacks the stem near the soil surface, but under favorable conditions it can infect almost all parts of the plant, including roots, leaves, petioles, flowers, and even fruits. The earliest signs of infection are gradual yellowing and wilting of leaves, which often alert farmers to the problem. As the disease progresses, a thick white, cottony (fluffy) fungal growth appears on the infected tissues and surrounding soil. One of the most distinctive features is the formation of small, round structures called sclerotia. These are initially white but later turn dark brown to black, resembling mustard seeds (Liang X and Rollins A, 2018).

Young seedlings are highly vulnerable and may die quickly after infection. In older plants, the fungus slowly damages the stem by forming lesions that girdle it, cutting off water and nutrient flow. This leads to severe wilting and eventual death of the plant. Infected tissues become soft and pale brown, though not watery. In some cases, the fungus may produce spores under very humid conditions, but this is rare (Mondal *et al.,* 2020).

Overall, the disease spreads rapidly and can cause significant plant loss, especially when stem rot develops near the base of the plant. Estimated yield losses of various crops due to *S. rolfsii* are listed in Table 1.

Table 1. Estimated yield losses of various crop due to *Sclerotium rolfsii*

Crop	Yield Loss
Chilli	16 – 80 %
Elephant foot yam	20 – 100 %
Pepper mint	5 – 20 %
Groundnut	55 – 80 %
Tomato	45 %

Cowpea	60 %
Chick pea	80 – 100 %
Brinjal	60 %
Betel vine	80 %
Bush bean	50 – 65 %
Rice	75 %

Infection Mechanism and Life Cycle

Sclerotium rolfsii is a soil-dwelling fungus that infects plants mainly at or near the soil surface. The infection begins when the fungus grows over the plant surface, forming a visible layer of white mycelium. This stage usually takes about 2 to 10 days, depending on environmental conditions (Mondal *et al.,* 2020).To enter the plant, the fungus produces enzymes that weaken and break down the outer protective layers of plant tissues. Once inside, it rapidly colonizes the plant, leading to tissue decay. During this process, the fungus also forms sclerotia small, hard survival structures that help it persist in the soil for long periods.

A key factor in its infection strategy is the production of oxalic acid along with powerful cell wall degrading enzymes such as cellulase and polygalacturonase (Motlagh *et al.,* 2022). Oxalic acid plays a major role by lowering the pH of plant tissues and removing calcium from cell walls, making them more vulnerable to enzymatic breakdown. Together, these substances destroy the plant's structural integrity, resulting in soft, decayed (macerated) tissues.

As the fungus continues to grow, it absorbs nutrients from the damaged plant tissues. This disruption blocks the movement of water and nutrients within the plant, ultimately causing symptoms like wilting, yellowing, and tissue death. Schematic representation of *Sclerotium rolfsii* in successful host infection is represented in Figure 1.

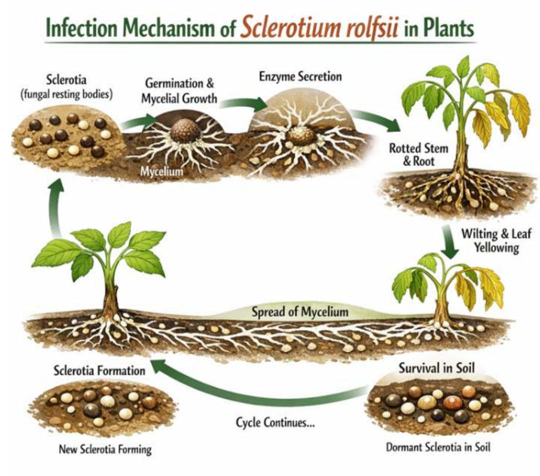

Figure 1. Infection Mechanism of *Sclerotium Rolfsii* in susceptible host plants

Biological Management: An Eco-Friendly Approach

The use of beneficial microorganisms is emerging as a sustainable and effective strategy to manage diseases caused by *Sclerotium rolfsii*. Instead of relying solely on chemical fungicides, farmers can apply these microbes to soil, seeds, or planting materials to suppress the pathogen and enhance plant health.Among the most widely studied beneficial microbes are bacteria such as *Bacillus*, *Pseudomonas*, and fungi like *Trichoderma*. These organisms act as natural enemies of *S. rolfsii* through mechanisms such as mycoparasitism (direct attack), competition for nutrients and space, and production of antimicrobial compounds.Among fungal biocontrol agents, *Trichoderma* species are the most effective and extensively studied. They directly attack the pathogen by penetrating and degrading the tough outer layer of sclerotia using enzymes like chitinase and β-1,3-glucanase (El-Ashmony *et al.,* 2022).

For instance, *Trichoderma virens* significantly reduces the growth of *S. rolfsii* through the production of gliotoxin, which damages the pathogen's structure.

Similarly, *Trichoderma harzianum* produces volatile compounds such as trans-2-octenal that inhibit fungal growth (Arshath *et al*., 2024). Under greenhouse conditions, *Trichoderma viride* has shown strong suppression of stem rot in groundnut, while *Trichoderma koningii* exhibits effective mycoparasitic activity in crops like tomato.

Bacterial biocontrol agents, particularly *Bacillus* species, are also highly promising. *Bacillus velezensis* has been reported to control *S. rolfsii* in groundnut by inducing plant defense mechanisms. In chickpea, seed treatment with *Bacillus subtilis* significantly reduces disease incidence and enhances defense-related enzymes. Another species, *Bacillus amyloliquefaciens*, not only suppresses the pathogen but also improves nutrient availability, promoting better plant growth (Jia *et al*., 2023). In addition, *Pseudomonas fluorescens* can inhibit fungal growth and reduce sclerotial germination.Other beneficial fungi such as *Gliocladium*, *Penicillium*, and *Glomus* have also shown potential in suppressing *S. rolfsii*, either through direct antagonism or by enhancing plant resistance.

Overall, biological control offers an eco-friendly and sustainable alternative for managing *Sclerotium rolfsii*, reducing dependence on chemical fungicides while improving crop health and productivity.

Conclusion

Sclerotium rolfsii remains a major constraint to crop production due to its wide host range, persistent survival through sclerotia, and aggressive infection at the soil level. Conventional chemical control methods alone are often inadequate and raise environmental concerns. Biological management has emerged as a highly promising and sustainable alternative. Beneficial microorganisms such as *Trichoderma*, *Bacillus*, and *Pseudomonas* effectively suppress the pathogen through mechanisms like mycoparasitism, antibiosis, competition, and induction of plant defense responses. These bioagents not only reduce disease incidence but also improve plant growth and soil health. Advances in the use of endophytic microbes, microbial consortia, and bioformulations further strengthen their potential under field conditions.Therefore, integrating biological control agents with good agronomic practices offers a reliable and eco-friendly strategy for managing *Sclerotium rolfsii* and ensuring sustainable crop production.

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