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Management of collar rot of elephant foot yam caused by *Sclerotium rolfsii* Sacc. - A Review

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Abstract

Tuber crops are the third most important food crop for man after cereals and grain legumes. Among them Elephant foot yam (*Amorphophallus paeoniifolius*), “King of tuber crops”, is important commercial tuber crops of tropical and subtropical region of the world. But Collar rot is one of the important fungal disease (caused by *Sclerotium rolfsii*) reducing the quality and quantity of corms in *Amorphophallus*. Though chemical measures are recommended based on the previous studies on *Sclerotium* spp., the new fungicides along with earlier proven fungicides need to be evaluated to find out the superior fungitoxicants with which the disease can be controlled. Presently, greater emphasis should be placed on biological control of soil borne pathogens in order to reduce the environmental hazards, to avoid the development of resistant strains and to reduce the cost of cultivation. Hence, an integrated approach plays an important role in the effective management of collar rot of the Elephant foot yam caused by *Sclerotium rolfsii*. In this connection, the literature on various aspects related to the proposed study was collected and summarized in this chapter.

Keywords: *Amorphophallus paeoniifolius*, Bio-agents, Botanical Control, Chemical control, Collar Rot, Integrated Management of collar rot, Organic amendments, *Sclerotium rolfsii* Sacc

Introduction

About the pathogen *Sclerotium rolfsii*

Sclerotium rolfsii Sacc. is being well known polyphagous, ubiquitous omnivorous and most destructive soil borne fungus. This was first time reported by Rolfs (1892) [44] as a cause of tomato blight in Florida. Later, Saccardo (1911) [45] named the fungus as *S. rolfsii*. But in India, Shaw and Ajrekar (1915) [50] isolated the fungus from rotted potatoes and identified as *Rhizoctonia destruens* Tassi. However, the later studies showed that the fungus involved was *S. rolfsii* (Raj *et al.* 2009) [38].

Higgins (1927) [18] worked in detail on physiology and parasitism of *S.rolfsii*. However, its perfect stage was first studied by Curzi (1931) [14] who proposed generic name as *Corticium*.

Mundkar (1934) [31] successfully isolated the perfect stage of *S. rolfsii*. The pathogen, *Sclerotium rolfsii* Sacc. is distributed in tropical and subtropical regions of the world where high temperature prevail. The fungus has a wide host range of 500 species in about 100 families including groundnut, green bean, lima bean, onion, garden bean, potato, sweet potato and water melon (Aycock 1959) [5]. The teliomorph of *S.rolfsii* was first placed in *Corticium centrifugum* (leu.) Bres. Later *Corticium rolfsii* was proposed to be the basidial state of *S. rolfsii* by Cruze (1931) [14]. Talbot (1973) [53] suggested that the basidial state of *S. rolfsii* belonged to the genus *Athelia*.

Morphology of *Sclerotium rolfsii*

Ansari & Agnihotri (2000) [1] studied the morphological, physiological and pathological variation among *S. rolfsii* isolates of soybean 44 isolates of *S. rolfsii* were categorized to in various group based on morphological characteristic of sclerotia and its arrangement on semi-synthetic medium.

Chand *et al.* (2003) [12] while studying biology of the aquatic isolates of *S. rolfsii* reported that all the isolates produced mycelium with different growth pattern. In lotus isolate, growth pattern was radiate while in water chest nut & duck weed isolate fluffy growth were recorded. Brown to black, smooth & scattered sclerotia were observed.

Jadon and Tiwari (2011) [22] studied on pathogen physiology & management of brinjal collar rot caused by *S. rolfsii*. Potato sucrose agar and potato dextrose agar (10mm) were found to be best for mycelial growth of the pathogen where as good sclerotia production was obtained in Kings B (180) & soybean leaf medium (120). The optimum mycelial growth of 89.33mm and 84.00mm was recorded at 30°C temperature and 5.0 pH where as maximum sclerotia production of 181.66 and 107 occurred at 25°C and pH 7.0, respectively.

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Rakholiya and Jadeja (2011) [40] studied morphological variation of thirty isolates of *S. rolfisii* for colony morphology, mycelial features, growth rate and sclerotium formation, size, colour, number, weight, arrangement & maturity days of sclerotia. *S. rolfisii* is a potential pathogen against many host plants. *S. rolfisii* was isolated from different growing areas of Gujarat and compared with other isolates. Significant variations were observed in most of the morphological characteristic of mycelium & sclerotium of different isolates of *S. rolfisii*. The white colonies were produced by most of the isolates except in four isolates, which showed dull white colonies sclerotia were light brown to dark brown in colour whereas, one isolates differed in sclerotial. All the isolates between 1.0 to 1.7 mm. The sclerotial weight of most of isolates was between 3.3 to 12.0 mg/ 10 sclerotia. Maximum weight of sclerotia was observed in the same isolate that produce deep brown sclerotia (26 mg/10 sclerotia).

Symptomatology of *Sclerotium rolfisii*

Kalmesh and Gurjar (2001) [25] described the symptom of root rot of chilli caused by *S. rolfisii*. A severe mortality of chilli plants was observed during March-April in chilli growing areas. Mature plants of chilli from standing crop were collapsed and dried down suddenly. Close examination of the diseased plants showed deep cracks near collar region. Roots were shredded and unhealthy with full of white mycelium growth on the surface of freshly infected area.

Gogoi *et al.* (2002) [17] described the collar rot symptoms on *Amorphophallus companulatus* Brume. The infected plants showed shrunken and brown coloured bark first on the collar region that later spread to roots. When the bark was peeled off, the inner tissue showed brown to black discoloration. The roots of the affected plants were found rotten. Yellow to pink discoloration of leaves followed by shedding and ultimately leading to drying of plants was also observed.

Arunasri *et al.* (2011) [4] described the symptoms of collar rot of EFY caused by *S. rolfisii*. The fungus *S. rolfisii* induced a variety of symptoms such as seed rots, seedling blight, collar rot, stem rot and wilt in different crops.

Distribution and economic importance of *Sclerotium rolfisii*

The pathogen attacks more than 500 species including vegetables, flowers, cereals, forage crops and weeds. Some of the common host includes legumes, crucifers, tomato, chrysanthemum, peanuts and tobacco in which the pathogen caused foot rot or root rot (Anahosur, 2001) [1]. The pathogen caused a great economic loss in various crops. In groundnut, it caused 25 per cent of seedling mortality (Ingale and Mayee, 1986) [19]. Thiribhuvanamala *et al.* (1999) [55] observed that 30 per cent of crop losses in tomato was due to *S. rolfisii*.

Effect of soil moisture on *Sclerotium rolfisii*

Reddy *et al.* (1972) [43] and Ramarao and Raju (1980) [42] conducted a series of laboratory experiments with *S. rolfisii* isolated from wheat and recorded the highest mortality of seedlings at 25 per cent moisture holding capacity of soil. They also noticed least per cent disease incidence at 40 per cent soil moisture.

Katti *et al.* (1983) [27] reported that the survival of *S. rolfisii* was highest at soil moisture levels between 30 and 50 per cent.

Nargund *et al.* (1983) [32] observed that the wheat seedlings survival and yields were considerably higher in sick soil plots receiving 4-6 irrigations than those with 1-3 irrigations.

Palakshappa (1986) [33] studied the effect of different soil

moisture levels on foot rot of betelvine caused by *S. rolfisii* and reported that the fungus survived better at low soil moisture than at higher levels. The survival ability was highest between 20 and 40 per cent soil moisture. However, higher saprophytic activity of the fungus was observed at 40 per cent moisture level and the least was at 60 and 70 per cent soil moisture where the saprophytic activity of the fungus was found to be very less.

In vitro evaluation of Botanical control

Bhaskar and Ali (2005) [10] reported that 3 leaf extract, i.e. Neem (*Azadirachta indica*), *Pongamia glabra* (*P. pinnata*) and *Annona squamosa* (ASLE) were effective in reducing PWL of the corms when kept for 30 days after inoculation.

Isidron *et al.* (2005) [20] found that plant extract of *Phyla strigullosa* var *sericea* (Mart and Gal) Moldenke (orozuz) on *S. rolfisii* which caused root & shoot rot on young susceptible crop. These extracts showed inhibitory activity against *S. rolfisii*.

Singh *et al.* (2007) [52] evaluated nine botanicals *in vitro* against *S. rolfisii* causing collar rot of lentil (*Lens culinaris*). Among them, the leaf extract of marigold (*Tagetes erecta*) followed by neem extract (*Azadirachta indica*) showed maximum reduction in growth and sclerotial production, its size and viability.

Mundhe *et al.* (2009) [30] while studying the efficacy of plant extracts against *Sclerotium rolfisii* showed maximum per cent inhibition due to Sarphagandha (87.77%) followed by Neem (85.88%) and sadafuli (83.33%). However, Glyricidia (25.22%), Tulsi (24.44%), Karanj (14.11%) and Bougainvillea (12.22%) were less effective. Glyricidia and Tulsi leaf extract were less effective and were at par with each other. Karanj and Bougainvillea were also less effective over control.

In vitro and *In vigo* evaluation of chemicals

Thakur *et al.* (2002) [54] tested six fungicides viz., bavistin (Carbendazim), thiram, benomyl, captan, prochloraz and mancozeb for their efficacy against the collar rot (*Sclerotium rolfisii*) of chickpea in pot culture. Bavistin, benomyl and captan were significantly superior to the other fungicides and reduced colony diameter to 1.09cm, 2.14cm and 2.77 cm, respectively (compared with 8.60 cm in control). These respective fungicides also recorded the lowest collar rot infection (11.0, 22.0 and 27.6%), the highest chickpea seed germination (91.6, 83.3 and 75.0%), and high values for shoot and root length, fresh and dry weights, and nodules per plant. Singh *et al.* (2004) [51] evaluated the effect of different concentration of six fungicides on the incidence of collar rot disease of betelvine caused by *S. rolfisii*. 3-thioallophanate and Mancozeb effectively controlled the collar rot disease when applied as soil drench.

Bhardwaj and Raj (2004) [9] reported the effect of mulching with transparent polyethylene and root dip in fungicide for the management of collar & root rot of strawberry. They observed that soil solarization for 40 days completely inhibited the sclerotia of the fungus buried at 7 cm soil depth. The treatments involving drenching, root dip + drenching with fungicide and root dip of strawberry runners in fungicide followed by planting in solarized plots were tested for management of the disease. Root dip strawberry runners in Saaf and Companion followed by their plantation in solarized plot found most effective in comparison to 38.1% incidence of disease in unsolarized plots.

Woodward *et al.* (2008) [56] evaluated full fungicide

programme, reduced fungicide programme and seven spray chlorothalonil programme. Fungicide programmes provided adequate levels of leaf spot suppression, and stem rot incidence was similar among fungicide programmes within the two management system. In the cultivar experiment, returns were significantly lower for the reduced program compared with the full program and seven-spray chlorothalonil programmes however, they were significantly higher than the non treated control. Significant differences in leaf spot, stem rot, and yield were observed among cultivars in both experiments.

Johnson *et al.* (2008) [23] reported that among the five pesticides tested for their efficacy, hexaconazole (1000, 1500 & 2000 ppm) and propiconazole (500, 700 & 1000 ppm) completely inhibited the growth of *S.rolfsii*.

Woodward *et al.* (2010) [57] reported that incidence of stem rot caused by *Sclerotium rolfsii* was lower in plot treated with soil borne based programmes than those treated with foliar based programmes.

Effect of organic amendments against collar rot of Elephant foot yam

Ramamoorthy *et al.* (2000) [41] screened six organic amendments viz., mahua cake, neem cake, groundnut cake, gingelly cake, compost and farmyard manure for the management of *Sclerotium* wilt (caused by *Sclerotium rolfsii*) of Jasmine (*Jasminum sambac*). Pot soil incorporated with different organic amendments recorded the minimum population irrespective of the different organic amendments.

Mukherjee & Dasgupta (2006) [29] cultured the antagonist on wheat and bajra seed for 30 days and then 10, 30 & 60 gm of inoculums was mass multiplied in 10 gm of vermi-compost, cow dung manure & mustard oil cake for 21 days. The best control of basal rot (77.40%) was obtained with 10g/40m² of inoculum grown on bajra seed & mass multiplied on vermi-compost.

Sahni *et al.* (2008a) [46] tested non-conventional chemicals, ZnSO₄ (10¹⁰mm) and oxalic acid (4mm) alone as well as in combination with seed bacterized with *Pseudomonas syringae* strain PUR46 and vermi-compost substitution in the potting soil for their ability to suppress collar rot of chickpea (*Cicer arietinum*) caused by *Sclerotium rolfsii* under green house condition.

Sahni *et al.* (2008b) [47] adopted an integrated approach by using vermi-compost & an antagonistic strain of *Pseudomonas syringae* (PUR46) possessing plant growth – promoting characteristics. Treatments with vermi-compost (10%, 25% & 50% v/v) and PUR46 alone and in combination reduced seedling mortality in chickpea under greenhouse condition.

In vitro and In Vivo Evaluation of Bio - agents

Biswas & Sen (2000) [11] conducted dual culture test for eleven isolates of *Trichoderma harzianum* with *S.rolfsii*. Three isolates viz. T₈, T₁₀ & T₂ were effective against *Sclerotium rolfsii* [*Corticium rolfsii*] the causal agent of stem rot of groundnut. The spores remained viable only up to a week of storage at room temperature on seeds when the seeds were coated with bio control agent by rolling seeds on a colony of *Trichoderma* in petri dishes.

Parakhia & Akbari (2004) [35] evaluated different soil amendments against collar rot of groundnut. They reported that all the amendment carriers were found effective in reducing the disease and improving the yield except caster shell. Minimum disease incidence (19.65%) was recorded in

wheat husk which recorded highest pod yield of 1317 kg /ha. Chandrasehar *et al.* (2005) [13] conducted laboratory and greenhouse experiments to determine the efficacy of antagonistic microorganisms i.e., *T.harzianum*, *T.viride*, *Aspergillus niger*, *Aspergillus terreus*, *Aspergillus flavus* and *Pseudomonas fluorescens* against *sclerotium rolfsii* that causes tomato collar rot. *In vitro* evaluation of antagonists revealed that *T.harzianum* and *T.viride* overgrew and completely suppressed the growth of *S.rolfsii*.

Singh *et al.* (2006) reported that the antagonist mixture of *T.harzianum* + *Pseudomonas fluorescens* in (1:1) ratio was found to be best for collar rot management and yield increase.

Babu and Kumar (2008) [6] reported that among nine antagonists of rhizosphere fungal mycoflora of groundnut, *Trichoderma harzianum*-3 (Th-3) inhibited mycelial growth of *S.rolfsii* by 63% in dual culture, the sclerotial population was also reduced drastically when compared with 540 found in untreated control plates. One of the five bacterial antagonist from rhizosphere of groundnut, *Pseudomonas fluorescens*-1 (Pf-1) was found very effective as it totally inhibited mycelial growth and sclerotial population of *S.rolfsii*.

Joshi *et al.* (2008) [24] reported the antagonistic potential of 17 fungal isolates 15 *Trichoderma harzianum* and 2 *Fusarium solani* [*Haemotonectria haematococca*] isolates, indigenous to the western Himalayan region of India. These isolates have the potential to parasitize *S.rolfsii* especially in the wilt region of India.

Kapoor (2008) [26] reported that *in vitro* studies on the efficacy of *Trichoderma spp.* against soil borne pathogen revealed maximum inhibition of mycelial growth by *T.viride* against *S.rolfsii*.

Pan and Jash (2009) [34] collected ten isolates of *Trichoderma spp.* from diverse agro-ecological habitat of West Bengal and evaluated against the sclerotial pathogens for variability in antagonistic potential. *T.viride* (TV-45) was the highly antagonistic against *S.rolfsii*.

Rakh *et al.* (2011) [40] made an attempt to develop effective biocontrol for management of stem rot disease caused by *Sclerotium rolfsii* in groundnut. *Pseudomonas spp.* isolated from rhizospheric soil were evaluated for their antagonistic soil activity against *S. rolfsii*. In pot assay for control of *S. rolfsii*, *Pseudomonas cf. montelii* 9 showed decrease in incidence of disease up to 45.45 to 66.67% in comparison to untreated seeds.

Bhagat & Pan (2011) [8] reported that twelve isolates of *Trichoderma spp.* were evaluated for their competitive parasitic ability against sclerotia of *Sclerotium rolfsii* by using as live baits under pot condition. Lowest collar rot incidence in brinjal was noted with the WB -1 (T3 seed + soil application) & highest reduction in disease incidence (77.1%) was recorded with seed & soil application of some isolate followed by TvAN - 3 (T₁₂), ThrAN-5 (T₆), TvAN-5 (T₁₅) where as the isolate ThrAN-13 was least effective.

Integrated Management of collar rot caused by Sclerotium rolfsii

Dutta and Das (2002) [15] studied the efficacy of three *Trichoderma spp.* and two seed dressing fungicides for the management of collar rot of tomato caused by *S.rolfsii*. Observations on inhibition of mycelial growth & number of sclerotia produced were recorded after seven & thirty days respectively. He also reported the efficacy of *T.harzianum*, *T.viride* & *T. koningii* & 2 seed dressing fungicides [0.1% thiram & 0.1% Dithane M-45 (Mancozehl)] for the management of collar rot of tomato caused by *Sclerotium*

rolfsii under laboratory & field condition. *T.harzianum* was the most inhibitory to *S.rolfsii* which showed 61.4% inhibition in mycelial growth, and reduced 90% sclerotial production followed by *T.viride* (86.8%) & *T.koningii* (84.1%), Dithane M-45 was the most effective in inhibiting mycelial growth (76.5%) & sclerotial production (98.6%). Fungicide treated seedlings showed minimum disease incidence as compared to biocontrol agents and there was improvement in the growth characters & yield.

Gogoi *et al.* (2002) [17] reported the efficacy of *Trichoderma harzianum* and *Bacillus subtilis* (alone & in combination with 0.2 % captan) against collar rot of EFY caused by *S.rolfsii*. Soil drenching with Captan exhibited the lowest disease incidence (12.9%) among all the treatments. The combinations of corm+soil treatment with Captan was satisfactorily at par with corm+ soil treatment with *T. harzianum*. Corm treatment with *T. harzianum* followed by soil drenching with captan inhibited the growth of the antagonist. In all the treatments the population density of *S.rolfsii* significantly decreased compared to the control.

Patibanda *et al.* (2002) [36] determined the feasibility of using *T.harzianum* for the management of sclerotium wilt in groundnut. *T.harzianum* application either to soil as wheat bran saw dust (WBSD) preparation or on the groundnut seeds as spore coat proved effective against Sclerotium wilt caused by *S.rolfsii*. Integration of Thiram (seed coating) and soil application of antagonist was found compatible and synergistic. However, seed treatment with both antagonist & Thiram was found incompatible and hence may not be practically feasible for disease reduction.

Prabhu and Patil (2004) [37] reported the effect of systemic fungicides (carboxin, carbendazin, benomyl, thiophanate methyl, fosetyl aluminium, 63% carbendazin + 12% mancozeb & propiconazole at 0.05, 0.10 or 0.20%) and non-systemic fungicide (thiram, mancozeb, captan, zineb and chlorothalonil at 0.1, 0.2 or 0.3%) & biological control agents (*Gliocladium virens*, *Trichoderma harzianum*, *T.koningii*, *T.pseudo koningii*, *Pseudomonas fluorescens*, *Bradyrhizobium japonicum*, *P.striata* & *Bacillus subtilis*) on the mycelial growth of *S.rolfsii* *in vitro* were studied. The inhibition of mycelial growth increased as the fungicide concentration increased. The greatest mean per cent inhibition was recorded for carboxin, carbendazin + mancozeb, propiconazole and Thiram (100%) as well as for *T.harzianum* (79.03%).

Khosla and Kumar (2005) [28] studied the control of root rot of strawberry caused by *S.rolfsii*. The fungicides & biological control agent were tested alone and in combination of different concentration for two consecutive years. Data varied from 56.47% disease control by Bavistin (carbeendazin) (0.2%) when applied alone to 82.58% disease control by combination treatment of thiram & *Trichoderma viride* talc formulation (0.4+0.5%). *Trichoderma* individually (1%) gave 72.9% disease control where thiram (0.4%) controlled the disease to an extent of 67.25%.

Saralamma and Reddy (2005) [49] reported the efficacy of biological agents (*T.H*, *T.V*, Thiphanate-methyl and neem cake), singly or in combination against root rot cause by *Sclerotium rolfsii*. As seed treatment, the BCAs were used at 10^8 conidia /ml when applied singly, but used at half the rate when combined with fungicide. Neem cake was applied at 100 kg/ha. BCAs + Fungicide + Neem Cake resulted in antagonist population of 24.5×10^3 and 26.1×10^3 cfu/g of soil in 1997 & 1998, respectively. The BCAs were most effective when applied to soil than to seeds.

Islam and Bhuiyan (2006) [21] reported on the basis of pot & field experiment under inoculated condition through integration of *Trichoderma* isolate with vitavax-200 (carboxin+thiram). Integration of wheat grain colonized *Trichoderma* with vitavax-200 as soil drenching was found to be most effective against foot & tube rot of tuberose. Efficacy of the individual components was improved when they were applied in the integrated approach.

Ganesan *et al.* (2007) [16] studied that integrated management of stem rot disease of groundnut using a combined application of *Rhizobium* & *Trichoderma harzianum* (ITCC-4572) was performed. The application of native microorganism successfully decreased stem rot incidence and also increased plant growth. The plant growth promoting activity and disease control ability of these microbial agents are also discussed.

Banyal *et al.* (2008) [7] evaluated ten fungicides namely carbendazin 50WP, carbendazin + mancozeb 75 WP, captan 50 WP, thiabendazole 80 WP, mancozeb WP, carboxin 75 WP, propineb 70WP, mancozeb 75WP, tebuconazole 5 DS and *T. viride* (Ecoderma) against *S. rolfsii* causing collar rot of tomato. Tebuconazole & carboxin 50 µg/ml gave complete inhibition of mycelial growth of the pathogen. Seedling dip with tebuconazole & carboxin gave a total control of the disease in pots. Integrated effect of soil application of *T. viride* (local strain), seedling dip with tebuconazole (0.05%) and soil drenching with tebuconazole (0.05%) resulted in complete control of collar rot of tomato in pot culture.

Sai *et al.* (2010) [48] reported that integrated management of the disease caused by *S.rolfsii* with bio control agent. Eight different isolates (TG₁ TG₂ TG₃ TG₄) isolated consistently from the rhizosphere of groundnut were used as treatments. Among them TG₂ isolate was found to be significantly superior over other in inhibiting the mycelial growth of *S.rolfsii* to the extent of 67.83%.

Ansari *et al.* (2011) [2] worked on collar rot of soybean against *S.rolfsii* and reported that both the species of *Trichoderma* checked the growth of *S.rolfsii*. Vitavax powder & thiram were compatible with *Trichoderma* and can be integrated for the management of the collar rot soybean.

Vikram and Hamzehzarghani (2011) worked on integrated management of *S.rolfsii* in groundnut using different bio control agents, chemical treatments & organic amendments. All treatments were inoculated with *S.rolfsii* & *Bradyrhizobium spp.* NC-92 at the time of sowing. All treatments recorded significantly lower percentage of pods infected with *S.rolfsii* & resulted in higher pod yield compared to untreated control. The highest pod yield was recorded in plants receiving *P.fluorescens* FPD-10. Most of the treatments tested in this trial reduced pod infection.

After scanning the literatures on different aspects of management of collar rot of elephant foot yam caused by *Sclerotium rolfsii* Sacc." it is understood that the research information on botanicals, bio-agents, organic amendments and chemicals for efficient management of collar rot in elephant footyam is meager and very little work has been done. Hence, an attempt has been made to evaluate the integrated management with botanicals, bio-agents, organic amendments and chemical in elephant footyam.

References

1. Anahosur KH. Integrated management of potato sclerotium wilt caused by *sclerotium rolfsii*. Indian Phytopath. 2001; 54:158-166.
2. Ansari MM, Agnihotri SK. Morphological physiological and pathological variation among *Sclerotium rolfsii*

- isolates of Soyabean. *Indian Phytopath.* 2000; 53(1):65-67.
3. Ansari MM, Mirza S, Gupta GK, Srivastava SK. Characterization of local isolates of *Trichoderma*, *in-vitro* evaluation against *Sclerotium rolfsii* (causal organisms of collar rot of soybean) and compatibility with seed dressing fungicides. Abstracts Soyabean Research, 2011; 9:123-135.
 4. Arunasari P, Chalam TV, Reddy ENP, Reddy TS. Collar rot disease of crossandra induced by *Sclerotium rolfsii* and its management: A critical review. I.J.A.B.T., 2011; 2(2):307-314.
 5. Aycock R. Stem rots and other disease caused by *Sclerotium rolfsii* North Carolind agricultural experiment station technical bulletin NO. 1959; 174:202.
 6. Babu KV, Kumar RM. Mycoparasitic activity of *Trichoderma harzianum* against stem rot pathogen (*Sclerotium rolfsii*) of groundnut. *J. Mycol. Pl. Pathol.* 2008; 38(3):593-595.
 7. Banyal DK, Mankotia V, Sugha SK. Integrated management of tomato collar rot caused by *Sclerotium rolfsii*. *J. Mycol. Pl. Pathol.* 2008; 38(2):164-167.
 8. Bhagat S, Pan S. Parasitic ability of *Trichoderma* isolates against sclerotia of *Sclerotium rolfsii* and management of collar rot of brinjal. *Biopesticides International*, 2011; 7(1):52-059.
 9. Bhardwaj U, Raj H. Mulching with transparent polyethylene and root dip in fungicides for the management of collar and root rot of strawberry. *Indian Phytopath.* 2004; 57(1):48-52.
 10. Bhaskar AV, Ali S. Occurrence, identification and management of soft corm rot (*Sclerotium rolfsii*) in cajucasia. *Science Journal.* 2005; 14(2):48-52.
 11. Biswas KK, Sen C. Management of stem rot of groundnut caused by *Sclerotium rolfsii* through *Trichoderma horzianum*. *Indian Phytopath.* 2000; 53(3):290-295.
 12. Chand R, Verma R, Singh SK, Chaurasia SK, Lal M. Biology of the aquatic isolates of *Sclerotium rolfsii*. *Indian Phytopath.* 2003; 56(3):293-294.
 13. Chandrasehar G, Ayyappan S, Eswaran A. Management of tomato collar rot caused by *Sclerotium rolfsii* by antagonistic micro organisms. *Journal of Ecobiology.* 2005; 17(3):261-264.
 14. Curzi M. Alcuni Csidi 'cancrena pedale' da *Sclerotium* osservati in India. *Atti Acord Na₂ lincei RC.* 1931; 14:233-236.
 15. Dutta Pranab, Das BC. Management of collar rot of tomato by *Trichoderma* spp. and chemicals. *Indian Phytopath.* 2002; 55(2):235-237.
 16. Ganesan S, Kuppusamy RG, Sekar R. Integrated management of stem rot disease (*Sclerotium rolfsii*) of groundnut (*Arachis hypogaea* L.) using *Rhizobium* and *Trichoderma harzianum* (ITCC-4572). *J. Agric. and Fores.* 2007; 31(2):103-108.
 17. Gogoi NK, Phookan AK, Narzay BD. Management of collar rot of elephant's foot yam. *Indian Phytopath.* 2002; 55(2):238-240.
 18. Higgins BB. Physiology and parasitism of *Sclerotium rolfsii*, 1927.
 19. Ingale RV, Mayee CD. Efficacy and economics of some management practices of fungal disease of groundnut. *J. Oilseed Res.* 1986; 3:201-204.
 20. Isidron P, Hernandez M, Campos B, Leon Aguilar AL. Fungicidal or Fungistatic effect of a plant extract on plants susceptible to the plant pathogenic soil fungus *Sclerotium rolfsii* Sacc. under protected cropping condition. [Spanish] CAB Abstract, 2005; XVLL-697-643.
 21. Islam MM, Bhuiyan MKA. Integrated management of foot and tube rot of tuberose (*Popianthes tuberosa*) caused by *Sclerotium rolfsii*. *J.Pl. Pathol.* 2006; 22(2):49-53.
 22. Jadon KS, Tiwari PK. Pathogen physiology and management of brinjal collar rot caused by *Sclerotium rolfsii*. *Ann. Pl. Prot. Sci.* 2011; 19(1):113-117.
 23. Johnson M, Reddy PN, Reddy DR. Comparative efficacy of rhizosphere mycoflora, fungicides, insecticides and herbicides against groundnut stem rot caused by *S.rolfsii*. *Ann. of Pl. Prot. Sci.* 2008; 16(2):414-418.
 24. Joshi D, Hooda KS, Bhatt JC. Bicontrol potential of fungal antagonists from western region against *Sclerotium* plant pathogen. *Pesticide Res. J.* 2008; 20(1):1-5.
 25. Kalmesh M, Gurjar RBS. *Sclerotium rolfsii* a new threat to chilli in Rajasthan. *J. Mycol. Pl. Pathol.* 2001; 31(2):261.
 26. Kapoor AS. Bicontrol potential of *Trichoderma* spp. against important soil born disease of vegetable crops. *Indian Phytopath.* 2008; 61(4):492-498.
 27. Katti DVS, Bhargava SN, Shukla DN. Some studies on the saprophytic survival of *Sclerotium rolfsii* in soil. *Z. Pflaslranks Pflpath Pllschute*, 1983; 90:382-387.
 28. Khosla K, Kumar J. Management of root rot and blight (*Sclerotium rolfsii* Sacc.) of strawberry. *Acta Horticulturae*, 2005, 371-373.
 29. Mukherjee M, Dasguta B. Management of basal rot of betelive (*Piper bettle* L.) caused by *Sclerotium rolfsii* (Sacc) by using antagonist. *Environments & Ecology*, 2006; 24s(3a):860-863.
 30. Mundhe VG, Diwakar MP, Kadam JJ, Joshi MS, Sawant UK. *In vitro* evaluation of bio-agents and botanicals against *Sclerotium rolfsii* causing foot rot of Finger let (Nagli). *J.Pl. Dis. Sci.* 2009; 4(2):183-186.
 31. Mundkar BB. Perfect stage of *Sclerotium rolfsii* Sacc. in pure culture. *J. Agri Sci.* 1934; 4:779-781.
 32. Nargund VB, Kulkarni S, Hegde RK. Studies on foot rot of wheat caused by *Sclerotium rolfsii* Sacc. in Karnataka. II. Effect of number of irrigations on the incidence of foot rot of wheat caused by *S. rolfsii* Sacc. *Current Research*, 1983; 12:76-77.
 33. Palakshappa MG. Studies on foot rot of betel vine caused by *Sclerotium rolfsii* Sacc. in Karnataka. *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Bangalore, 1986.
 34. Pan S, Jash S. Variability in Sclerotial Antagonism of Mycoparasitic *Trichoderma* spp. against *Rhizoctoni solani* and *Sclerotium rolfsii*. *J. Mycol. Pl. Pathol.* 2009; 39(3):409-415.
 35. Parakhia AM, Akbari LF. Field evaluation of *Trichoderma harzianum* against stem rot (*Sclerotium rolfsii*) of groundnut. *J. Mycol. Pl. Pathol.*, 2004; 34(2):288-289.
 36. Patibanda AK, Upadhyay JP, Mukhopadhyay AN. Efficacy of *Tichoderma harzianum* Rifai alone or in combination with fungicide against *Sclerotium* wilt of groundnut. *J.Bio.Con.* 2002; 16(1):57-63.
 37. Prabhu HV, Patil PV. Efficacy of chemical and biological seed dressers and host resistance in the management of collar rot of soybean caused by *Sclerotium rolfsii* Sacc. *Soybean Research*, 2004; 2:41-45.

38. Raj Mithun, Jeeva ML, Pravi V, Archana PV, Mishra Kumar A. Characterization of smaller subunit Ribosomal DNA of *Sclerotium rolfsii* causing collar and Tuber in *Amorphophallus paeoniifallus*. J. R.C. 2009; 35(2):206-210.
39. Rakh RR, Raut LS, Dalvi SM, Manwar AV. Biological control of *Sclerotium rolfsii* causing stem rot of groundnut by *Pseudomonas cf. monteiuii*. Recent Res. Sci. & Tech. 2011; 3(3):26-34.
40. Rakholiya KB, Jadeja KB. Morphological diversity of *Sclerotium rolfsii* caused stem and pod rot of groundnut. J. Mycol. Pl. Pathol. 2011; 41(4):500-504.
41. Ramamoorthy V, Alice D, Meena B, Muthusamy M, Seetaraman K. Biological management of *Sclerotium* wilt of jasmine. Indan J. Pl. Prot. 2000; 28 (1):102-104.
42. Ramarao P, Raju U. Effect of soil moisture on development of foot and root rot of wheat and on other crops. Indian J. Mycol. Pla. Pathol. 1980; 10:17-22.
43. Reddy M, Patil R, Kulkarni BG. Studies on the influence of soil moisture in foot rot of wheat caused by *Sclerotium rolfsii* Sacc. Mysore j. Agri. Sci. 1972; 6:10-13.
44. Rolfs PH. Tomato blight some hints bulletin Fla. Agric. Experimentation Station, Sacc. *Phytopathology*, 1892; 17:417-448:18.
45. Saccardo PA. Notae Mycological. Annales Mycologici, 1911; 9:249-257.
46. Sahni S, Sarma BK, Singh KP. Management of *Sclerotium rolfsii* with integration of non- conventional chemicals, vermicompost and *Pseudomonas syringae*. J. Microbiol & Biotech. 2008a; 24(4):517-522.
47. Sahni S, Sarma BK, Singh KP. Management of *Sclerotium rolfsii* with integration of non-conventional chemicals, vermicompost and *Pseudomonas syringae*. *World J. Microbiol. & Biotechn.* 2008b; 24(4):517-522.
48. Sai LV, Anuradha P, Vijayalakshmi K, Reddy NPE. Biocontrol of stem rot of groundnut incited by *Sclerotium rolfsii* and *In vitro* compatibility of potential native antagonists with fungicides. J. of pure and Applied Microbiology. 2010; 4(2):565-570.
49. Saralamma S, Reddy TV. Integrated management of root rot of groundnut. Indian J. Pl. Prot. 2005; 33(2):264-267.
50. Shaw FJP, Ajrekar SL. The genus *Rhizoctonia* in India. Mem. Department of Agricultural Indian Bot. ser; 1915; 7:177-194.
51. Singh Anand, Chaurasia RS, Srivastava S, Singh HB. Field Evaluation of Fungicides for control of collar Rot disease of Betelvine caused by *S. rolfsii*. J. Mycol. Pl. Pathol, 2004; 34(3):870-873.
52. Singh SR, Prajapati RK, Srivastava SSL, Pandey RK, Gupta PK. Evaluation of different botanicals and non-target pesticides against *Sclerotium rolfsii* causing collar rot of lentil. Indian Phytopath. 2007; 60(4):499-501.
53. Talbot PHB. Aphylophorales. In: The Fungi. An Adanced Treatise vol. IV B Ainsworth Gc, Sparrow FK and Sussman AS(eds.), Academic press, New York, 1973, 337-344.
54. Thakur KS, Keshry PK, Tamrakar DK, Sinha SK. Studies of management of collar rot disease (*S. rolfsii*) of chickpea by use of fungicides. PKV Res. J. 2002; 26(112):51-52.
55. Thiribhuvanamala W, Rajeswari E, Sabitha Doraiswamy. Inoculum levels of *Sclerotium rolfsii* on the incidence of stem rot in tomato. Madras Agric. J. 1999; 86:334.
56. Woodward JE, Brenneman TB, Kemerait RC, Jr Smith NB, Culbreath AK, Stevenson KL. Use of resistant cultivars and reduced fungicide programmes to manage peanut disease in irrigated and non irrigated fields. *Plant Dis.* 2008; 29(6): 896-902.
57. Woodward JE, Brenneman TB, Kenmerait RC, Jr. Culbreath AK, Smith NB. Management of peanut diseases with reduced input fungicide programmes in fields with varying levels of disease risk. *C.Prot.* 2010; 29(3):222-229.