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ROLE OF FUNGAL SPECIES IN MANAGEMENT OF STEM ROT DISEASE OF GROUNDNUT (*Arachis hypogea* L.)

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Abstract:

Sclerotium rolfsii Sacc. is a destructive soil borne fungal pathogen infecting about more than 500 plant species worldwide including groundnut (Arachis hypogea L.). Groundnut is an important oil seed crop in the world. Sclerotium rolfsii Sacc. is one of the major production constraints of groundnut. The fungus infects lower stems of groundnut, which are in contact with the soil as well as pegs, pods, and roots. The traditional agricultural practice employed to control the plant disease have severe disadvantage and is not eco-friendly. Excessive use of chemical fungicides in agriculture has led to deteriorating human health, environmental pollution. Biological control offers an interesting alternative to fungicides for sustainable management of soil borne diseases. The use of fungi as biocontrol agent is greatly beneficial due to their metabolic diversity and their relative environmental safety, as they are primarily decomposers. Trichoderma harzianum, T. viride, Aspergillus sp, Fusarium sp, Gliocladium sp and Petriella sp are known to be important biocontrol agents.

Key words: *Groundnut, Stem rot, Sclerotium rolfsii Sacc, Biocontrol agents, Trichoderma sp.*

Introduction:

Groundnut (*Arachis hypogea* L.), an important oil seed crop in the world, belongs to family *Fabaceae*. Groundnut is the 4th most important source of edible oil, and is ranked as 3rd most important source of vegetable protein in the world (Smith, 2002). Groundnut is grown in nearly 100 countries. India is the second largest producer of groundnut after China. Groundnut is largest oilseed in India in terms of production. The most important groundnut growing countries are India, China, Nigeria, Sudan and USA (Handbook on Grading of food Grains and oilseeds). Groundnut is cultivated worldwide in an area of 28 M ha with a total production of 47 Mt averaging a productivity of 1.6 t ha-1 (FAO, 2017). The leading producers of the groundnut crop include China (54%), India (22%), and USA (9.03%). In India, the crop is mostly grown in the states of Gujarat, Andhra Pradesh, Telangana, Tamil Nadu, Karnataka, Rajasthan, and Maharashtra constituting about 80 percent of the total area and production of groundnut.

The groundnut contains more protein (25-36 %) than meat, about two and a half times than in eggs, and far more than any other vegetable food except soybean and yeast. Groundnut seeds contain 46-52% oil content which is used for cooking purposes. It contains resveratrol, a polyphenol antioxidant, which has been found to have protective function against cancer, heart disease, degenerative nerve disease and viral infections. This signifies the importance of groundnut for human use and thus encourages for increasing its production and productivity.

Groundnut crop is prone to attack by different pathogens and to a much larger extent than many other crops. More than 100 pathogens have been reported to affect groundnut, but only a few are economically important in India such as leaf-spot (Tikka), early leaf-spot (*Cercospora arachidicola*), late leaf-spot (*C. personatum*), rust (*P. arachidis*), and aflatoxin contamination (*Aspergillus flavus* and *A. parasiticus*). The other diseases such as collar rot (*A. niger*), Stem-rot (*S. rolfsii*), root-rot (*M. phaseolina*), bud necrosis (tomato spotted wilt virus), clump and peanut (groundnut) mottle disease are localized (Subrahmanyam *et.al.*, 1980). In all these diseases of groundnut, one of the most emerging and rapidly spreading disease is the stem rot disease of groundnut caused by *S. rolfsii*. To control the plant diseases various traditional practices are being followed.

Stem Rot Pathogen:

The pathogen *Sclerotium rolfsii* Sacc., is a soil borne pathogen. It commonly occurs in the tropics, sub-tropics and other warm temperate regions of the world causing root rot, stem rot, wilt and foot rot on more than 500 plant species including almost all the agricultural and horticultural crops (Aycock, 1966; Domsch *et al.*, 1980; Farr *et al.*, 1989).

Sclerotium rolfsii was first reported by Rolfs (1892) later the pathogen was named as *Sclerotium rolfsii* by Saccardo (1911). Higgins (1927) worked in detail on physiology and parasitism of *S. rolfsii*. This was the first detailed and comprehensive study in USA. Sclerotia initially white in color, later it becomes light brown to dark brown at maturity and they are sub spherical, the surface finely wrinkled, sometimes flattened (Subramanian, 1964 and Mehan, 1995). This pathogen *Sclerotium rolfsii* forms brown sclerotia which are very well-organized compact structures, built of three layers, the rind, composed of empty melanized cells; the cortex cells, filled with vesicles and the medulla (Chet, 1975). Sclerotia may be spherical or irregular in shape and at maturity resemble the mustard seed (Taubenhaus, 1919; Barnett and Hunter, 1972). Sclerotial size was reported to be varied from 0.1 mm to 3.0 mm (Om Prakash and Singh, 1976; Ansari and Agnihotri, 2000 and Anahosur, 2001).

Disease symptoms:

The fungus infects lower stems of groundnut, which are in contact with the soil as well as pegs, pods and roots. Infected plants show wilting of one or few branches initially, but the whole plant may wilt and die within few weeks of infection. Whitish fungal mycelium and light-to-dark-brown sclerotia appear on the soil surface and diseased plant tissues (Lindermann and Gilbert 1973, Punja and Rahe, 1992).

Disease Cycle of Stem Rot Pathogen and its Dissemination:

The pathogen survives as a saprophyte on plant debris, even debris from non-host crops. Sclerotia survive well (3-4 years) at or near the soil surface but survive poorly when buried deep because the fungus has a high oxygen demand (Mehan *et al.*, 1994). Infection starts from sclerotia that germinate eruptively in the presence of volatile compounds from decaying organic matter under warm and moist conditions. As warm and moist climatic conditions favour disease development. The fungus mycelia colonize plant debris or other organic matter before infecting living plant tissue. Any part of the groundnut plant that comes in contact with the soil is infected with fungus. In warm and high moisture condition, the occurrence of stem rot usually coincides with early stages of peg and pod development. Stem rot develops at all the growth stages (10-90 days) but disease development is slow in older (more than 40 days old) plants than the younger plants (Pande *et al.*, 1994).

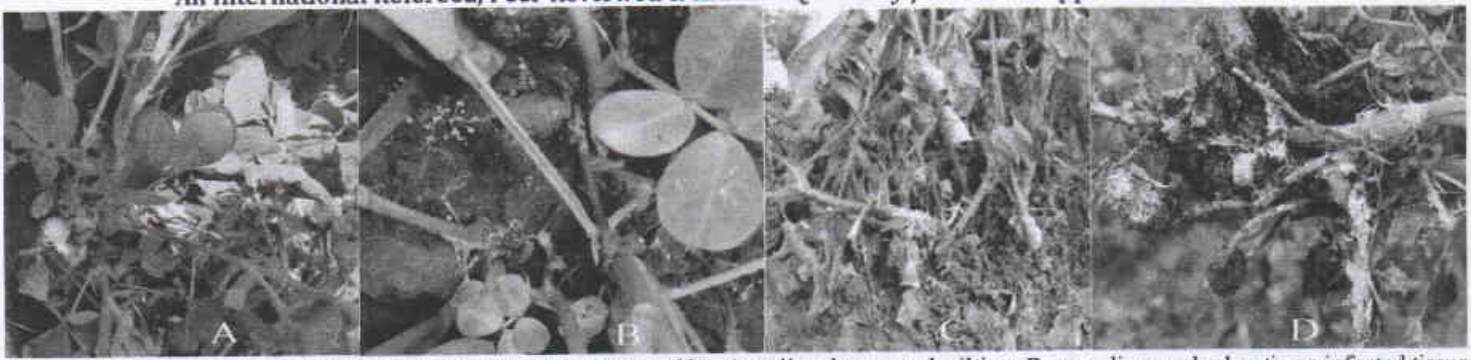

Figure 1. Disease symptoms on groundnut caused by *Sclerotium rolfsii*. A- yellow leaves and wilting; B- mycelium and sclerotia on infected tissue; C- stem rot symptoms; D- peg and pod rot.

Traditional Plant Disease Management Practices:

Traditionally the plant disease management can be classified as regulatory, cultural, biological, physical, and chemical, depending on the nature of the agents employed. Regulatory control procedures aim at excluding a pathogen from a host or from a certain geographic area. Most cultural control methods aim at helping plants to avoid contact with a pathogen, creating environmental conditions unfavourable to the pathogen or avoiding favourable ones, and eradicating or reducing the amount of a pathogen in a plant, a field, or an area. Finally, physical, and chemical methods aim at protecting the plants from the pathogen inoculum that has arrived, or is likely to arrive, or curing an infection that is already in progress (Agrios, 2005).

Application of fungicides gives effective control of stem rot in groundnut. The effectiveness of fungicides use is dependent upon the method of application, time of application, optimum dose, and weather factors. Stem rot is a seed and soil-borne disease so that it is important to treat the seed with vitavax @ 2 g/kg or tebuconazole @ 1.5 g/kg and spray tebuconazole @ 1 ml/l at 45 and 60 days after sowing for effective control of stem rot (Anonymous 2011). Application of tebuconazole 2 % DS @ 1g/kg seed before sowing provide excellent control of stem rot of groundnut (Gururaj, 2012).

The traditional agricultural practice employed to control the plant disease have severe disadvantage that it is not effective to check the pathogen and is not eco-friendly. However, excessive use of chemical fungicides in agriculture has led to deteriorating human health, environmental pollution, and development of resistance in pathogen to fungicide (Dalvi and Rakh 2017, Bolognesi and Merlo, 2019).

One of the most promising alternatives to synthetic fungicides is biological control of pathogens, which includes the use of biofungicides based on antagonistic microorganisms. In contrast to commonly used chemical fungicides, biofungicides have several advantages, i) high specificity against target pathogens, ii) rapid degradation in the environment and iii) low mass-production cost. Antagonistic microorganisms operate through various modes of activity such as competition with pathogens for space and nutrients, production of antibiotics, cell-wall degrading enzymes and reduction of pathogen population by hyperparasitism (Dimkić *et al.*, 2013, Stanojević *et al.*, 2016, Rakh *et al.*, 2019).

Fungi as biological control agents:

The control of fungal diseases of plants by the use of naturally occurring antagonistic microorganisms has been the focus of intense research throughout the world. This approach is popularly known as biological control of plant pathogens. Biological control is a bio-based, ecofriendly strategy offers a practical and economical alternative for the management of plant pathogens with a potential to emerge as an alternative to chemical control (Mark *et al.*, 2006).

The use of fungi as biocontrol agents is greatly beneficial due to their metabolic diversity and efficiency that enhances the chances of finding the apt isolates for biocontrol and their relative environmental safety, as they are primarily decomposers (Thomas and Read 2007).

Fungi belonging to genera *Aspergillus, Fusarium, Gliocladium, Petriella* and *Trichoderma* are known to be important biocontrol agents (De Silva *et al.*, 2019). The biocontrol activity of *Verticillium leptobactrum* against wilt disease induced by *Fusarium oxysporum, F. lycopersici* has been demonstrated by Hajji-Hedfi *et al.*, (2018).

Further many fungal biocontrol agents are also available as commercial products such as *Verticillium lecanii, Trichoderma polysporum, Trichoderma gamsii, Trichoderma asperellum, Purpureocilium lilacinum, Phlebiopsis gigantean, Paecilomyces lilacinus, Metarhizium anisopliae, Gliocladium catenulatum, Coniothyrium minitans, Candida oleophila, Beauveria bassiana, Aureobasidium pullulans* and *Ampelomyces quisqualis* (Larran *et al.*, 2016; Tranier *et al.*, 2014). The use of fungi as biocontrol agents is a safe and eco-friendly strategy towards sustainable agriculture. Furthermore, hidden possibilities or uses of fungi could be explored to enhance agricultural productivity, nano-agriculture, and metabolite production (Singh *et al.*, 2019).

Biswas and Sen (2000) reported that *Trichoderma harzianum* inhibit stem-rot of groundnut caused by *Sclerotium rolfsii*. Radawan *et al.*, (2006) reported that *Trichoderma harzianum* and *Trichoderma hamatum* were most effective against *Sclerotium rolfsii* and inhibited the mycelial growth by 79%. *Trichoderma species* have also been used in commercial enzyme productions like cellulases, hemicellulases, proteases and β-1, 3-glucanase (Verma 2007). The combination of *Rhizobium* and *T. harzianum* were significantly effective against *S. rolfsii* which caused stem rot disease and promote the plant growth and increase seed production of groundnut. *Trichoderma harzianum* has antagonistic activity against *Sclerotium rolfsii* as it produce antibiotics substance such as Viridin, gliotoxin, glioviridin, dermin and trichodermin (Eziashi 2006, Ghildiyal 2008).

Biological control has been proved to be a promising disease management technology especially against soil-borne plant pathogens. There are several soil fungi (*Trichoderma harzianum, T. viride, T. longibrachiatum* bacteria (*Pseudomonas fluorescens, Bacillus subtilis*) and mycorrhizal fungi found to be highly antagonistic to *S. rolfsii* and other soil-borne pathogens of groundnut. *Trichoderma viride* Tv1 was the most effective isolate against *S. rolfsii* with 69.40% growth inhibition followed by *P. fluorescens* resulting in 64.40% inhibition. Among the organic amendments tested in greenhouse, mahua cake with *T. viride* each @ 5 g/kg of seed resulted in 3.75% stem rot incidence as against 39.98% in control (Karthikeyan *et al.*, 2006). Seed treatment with *Trichoderma viride* or *T. harzianum* @ 10 g/kg seed and soil treatment @ 4 kg/ha with 250 kg castor cake helps in managing stem rot and other soil-borne diseases (Anonymous 2011). This showed a great potential for use of these microorganisms as biocontrol agents for controlling stem rot and other soil-borne pathogens.

Conclusion:

Stem rot is a major soil-borne disease of groundnut causing serious pod loss at harvest resulting great economic losses. The survey of available literature suggests that, the excessive use of chemical fungicides in agriculture has led to deteriorating human health and environment pollution. To overcome such problems biological control offers an interesting alternative to chemical fungicides for sustainable management of soil borne diseases. The use of fungi as biocontrol agent has been suggested for the management of soil-borne fungal pathogens.

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