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Evaluation of fungicides on *Sclerotium rolfsii*, Incitant of stem rot disease in groundnut (*Arachis hypogea* L.)

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Abstract
Groundnut is an important oilseed crop of India, grown extensively in various parts of the country. Stem rot caused by (*Sclerotium rolfsii* Sacc.) is the major disease, affecting the groundnut cultivation across the India and worldwide. Control of this pathogen is difficult as it produces sclerotia which overwinter in the soil to emerge as inoculum and cause the disease in following season. The main aim of this study was to evaluate the fungicides against stem rot of groundnut under *in vitro* conditions. Out of four fungicides screened, 100 per cent inhibition of *S. rolfsii* was observed with thiram and tebuconazole at both recommended and half the recommended dosages. Whereas, carbendazim and azoxystrobin recorded 76.29% and 89.07% respectively at the recommended concentration and at half the recommended concentration carbendazim and tebuconazole were recorded 34.29% and 83.14% respectively. The present findings suggest that thiram and tebuconazole were highly effective at recommended and half the recommended dosages.

Keywords: *Sclerotium rolfsii*, fungicides, stem rot

Introduction
Groundnut (*Arachis hypogea* L.) is commonly called peanut, goober pea, pindad jack nut, manila nut, pygmy nut, pignut and monkey nut (Rathnakumar *et al*. 2013) [19]. It is known as 'king of oil seeds (Aycock 1966) [1]. It belongs to the family of leguminaceae and originated from South America. It was cultivated as early as 1000 B. C. (Wiess 2000) [22]. Groundnut is one of the important oil seed crops of the world and major source of edible oil. The kernel contains 40–50% oil and 25–30% protein. It also contains 18% carbohydrates and minerals like Ca, Mg and Fe in higher levels in an available form, vitamins B1, B2 and niacin are present in a considerable level. It is used in hydrogenation and soap industries. After extraction of the residual oil, the cake contains 7–8% nitrogen, which is used both in fertilizer and cattle feed. The groundnut haulms provide nutritive fodder during summer season in dry farming area. It helps in improving soil fertility.

Groundnut is grown to an extent of 29.59 mha worldwide with a total production of 48.75 mt (FAOSTAT, 2019) [8]. In India, the crop is grown to an extent of 4.8 mha with a production of 9.2 mt (INDIASTAT, 2019). In Telangana state, it is grown to an extent of 0.13 mha with a production of 0.30 mt and productivity of 2364 kg ha^{-1} (Directorate of Economics and Statistics, 2019) [6].

The major production constraints are unreliable and erratic distribution of rainfall and appearance of unpredictable diseases and pests accounting for low productivity. Diseases are one of the major constraints responsible for the low productivity. Several fungal species have been reported to be associated with groundnut seed. Among the different pathogens attacking the crop, *Aspergillus niger*, *Aspergillus flavus*, *Rhizoctonia bataticola* and *Sclerotium rolfsii* are the most important fungi causing seed and seedling rots and stem rot diseases. Among the soil-borne fungal diseases, stem rot caused by *Sclerotium rolfsii* is a potential threat to successful groundnut cultivation. This disease causes severe damage near maturity and yield losses over 25% have been reported by Maya and Datar (1988) [16]. The *Sclerotium rolfsii* has an extensive host range, prolific growth rate and ability to produce large numbers of sclerotia that may persist in soil for several years (Punja, 1985) [17]. In India, the disease is more severe in Maharashtra, Gujarat, Madhya Pradesh, Andhra Pradesh, Orissa and Tamil Nadu (Krishnakanth *et al*., 1999) [14]. The stem rot caused by *Sclerotium rolfsii* Sacc. has been a major problem in groundnut growing regions.

The pathogen *Sclerotium rolfsii* Sacc., is a soil borne pathogen that 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 (Domsch *et al*., 1980; Farr *et al*., 1989) [7, 9]. This was first time reported by Rolfs (1892) [20] as a cause of tomato blight in Florida. Later, Saccardo (1911) [21] named the fungus as *S. rolfsii*. Symptoms are typified by the development of white fungal thread over the affected plant tissue. The disease starts with pre emergence rot of seeds characterized by rotten and softened seeds, which are covered by the white profuse mycelial growth of fungus. The pathogen attacks the germinated seedlings and causes wilt. In young seedling, a sheath of white muslin develops on or near the soil line around the affected area of the stem, which later turned to dark brown and small round bodies about the size of mustard like sclerotia seed are produced on the surface of infected tissue and the adjacent soil. Abundant sclerotia initially white and later turning brown, develop in the infected area. Young plants may be completely girdled and killed, a condition is known as foot rot. The pathogen attacks all the parts of the plant, but stem infection is most common and destructive yellowing and wilting of branches near the base is the first symptom. The main objective of present study is to find out the effective fungicides to manage the yield losses of groundnut due to stem rot pathogen.

Materials and Methods

Isolation and maintenance of the pathogen

Groundnut plants showing typical symptoms of stem rot collected during survey from different states were used for isolation of *S. rolfsii* separately by tissue segment method (Rangaswami, 1993) [18] using sterile Potato dextrose agar medium. The infected plants showing the presence of white mycelial mat with small round brown sclerotia near the collar region were pulled out and gently tapped to remove the soil and dirt particle. The infected portions of diseased plants collected from different area were cut into small pieces of 1 cm size using sterilized scalpel. These pieces were surface sterilized with 0.1 per cent sodium hypochloride for one minute and washed in sterile distilled water thrice and then placed at equidistance in a petri dish containing solidified Potato dextrose agar medium. These plates were incubated at 27±1°C in a BOD incubator for five days and observed for the growth of the fungus. The hyphal tips of fungi grown from the pieces were transferred aseptically to PDA slants for maintenance of the culture. The pathogen was identified as *S. rolfsii* based on the morphological characters as described by Punja (1985) [17].

In vitro evaluation of fungicides

The sensitivity of *S. rolfsii* isolates to four commonly used fungicides in groundnut cultivation *viz.*, Tebuconazole 2 DS (Raxil), Carbendazim 50 WP (Bavistin), Azoxystrobin 23.8 SC (Amistar) and Thiram 75 WP (Thiram) was studied at recommended and half the recommended concentrations using poison food technique. The fungicides measured as per the concentration to be tested and mixed with the Potato dextrose agar medium just before pouring into the petri dishes. Suitable controls were maintained without fungicide amendment. Mycelial discs of 6 mm diameter were cut from the margins of 5 day old actively growing cultures of each isolate and inverted in the centre of fungicide amended and un-amended PDA plates and incubated at 27±1 ºC. Colony diameters were measured when the full growth of isolates attained in control plates. Per cent growth inhibition was calculated in each treatment by comparison with control plates.

The per cent inhibition was measured by using the formula

$$I = \frac{C - T}{C} X\ 100$$

Where in,
I = Per cent inhibition of mycelial growth
C = Colony diameter in control (mm)
T = Colony diameter treatment (mm)

Results and Discussion

A total of four fungicides were evaluated for their bio-efficacy at recommended and half the recommended concentrations against *S. rolfsii* by using poisoned food technique and the results were presented in the (Table 1), (Plate 1).

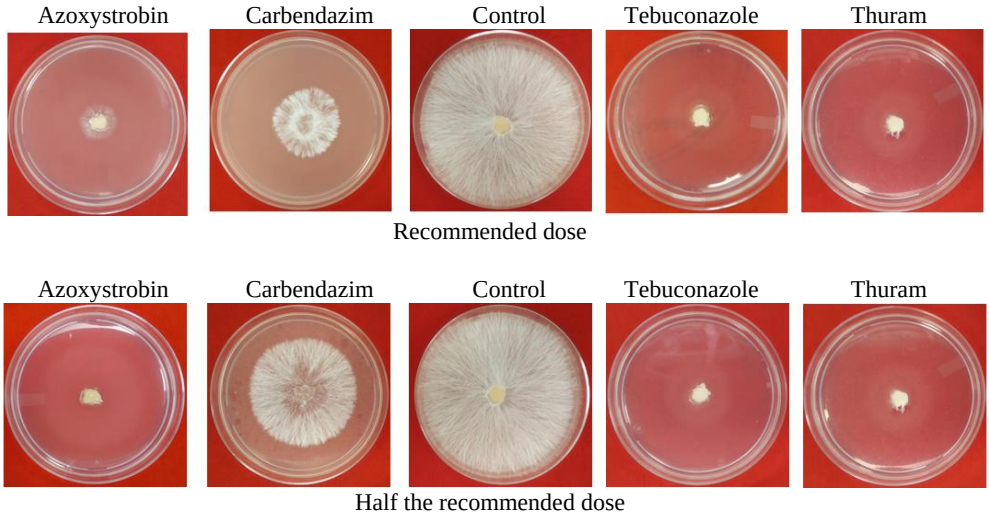

Plate 1: Sensitivity of *S. rolfsii* with fungicides at recommended dose and half the recommended dose

Table 1: Effect of fungicides on the mycelial growth of *Sclerotium rolfsii* causing stem rot of groundnut under *in vitro* conditions

Fungicides	Per cent inhibition of *Sclerotium rolfsii* over control	
	Concentration of fungicide	
	Recommended	Half recommended
Thiram	100	100
Carbendazim	76.29	34.29
Tebuconazole	100	100
Azoxystrobin	89.07	83.14

Factors	CD (0.01)	S.Em ±	CV (%)
Fungicides	1.17	0.39	1.83
Concentrations	1.66	0.55	
Interaction	2.35	0.78	

Out of four fungicides screened, 100 per cent inhibition of *S. rolfsii* was observed with thiram and tebuconazole at both recommended and half the recommended dosages. Whereas, carbendazim and azoxystrobin recorded 76.29% and 89.07% respectively at the recommended concentration and at half the recommended concentration carbendazim and tebuconazole were recorded 34.29% and 83.14% respectively and the difference between theses fungicides were significant at both recommended and half the recommended concentrations. Overall, the present findings suggest that thiram and tebuconazole were highly effective at recommended and half the recommended dosages.

Our findings are in agreement with (Brenneman and Murphy, 1991 and Besler *et al*., 2006) [4, 3] where in the fungicide used were found highly effective against stem rot of groundnut caused by *S.rolfsii* both under *in vitro* and *in vivo* conditions (Csinos *et al*., 1983) [5]. In the present studies the fungicide tebuconazole showed 100% inhibitions in the radial growth of pathogen, similar results were obtained by earlier workers (Gour and Sharma, 2010., Bhagwan, 2010) [12]. Similarly, Johnson and Subramanyam (2000) [13] observed complete inhibition of radial growth of *S. rolfsii* by tebuconazole and least inhibition with carbendazim. Likewise, Franke *et al*. (1998) [10] reported the higher efficacy of tebuconazole fungicide in controlling the stem rot of groundnut in Georgia under field conditions and *S. rolfsii* isolates under *in vitro* conditions. The fungicide thiram also showed complete inhibition in radial growth of *S. rolfsii* under *in vitro* conditions, similar results were found with thiram in *Trifolium* spp. by Bozarth and Tweedy, (1971) [11] where they found cent per cent inhibition in the growth of *S. rolfsii* under *in vitro* conditions. The result of present studies with regard to azoxystrobin is in agreement with work of Kumar *et al*. (2014) [15] with an inhibition of 45 per cent at 0.1% concentration.

In the study, tebuconazole was found to be most effective. The effectiveness was probably due to mode of action of tebuconazole (Bhagwan, 2010), which exhibited directional selection process in pathogen, indicating the resistance mechanism may be under the influence of many genes, or at least more than one (Franke *et al.*, 1998) [10].

Conclusion

In the present study the effective fungicides *viz*., Thiram and tebuconazole were proved most effective on the stem rot causing fungi *S. rolfsii*. They may probably act as antifungal agents and imparts its poisoning effect on metabolic process of pathogen, therefore, the growth of the *S. rolfsii* might be adversely affected.

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