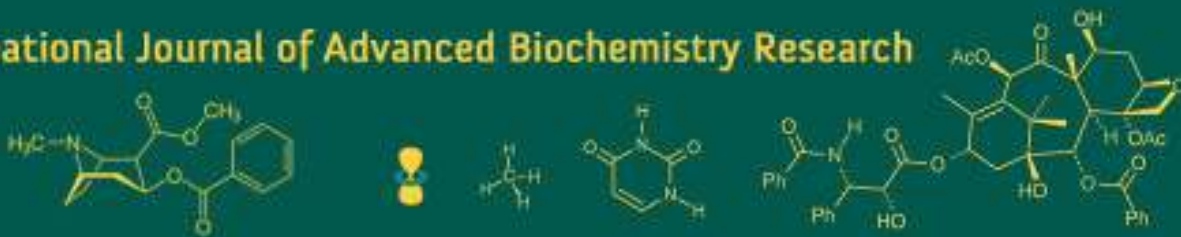


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Evaluation of potential actinomycetes Bioformulation on stem rot of groundnut caused by *sclerotium rolfsii*

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Abstract

Groundnut (*Arachis hypogaea*, L.) is one of the most important oil seed crops of India. Stem rot caused by *Sclerotium rolfsii* Sacc. is a major constraint in the production and productivity of the groundnut? Though chemical fungicides have played an important role in increasing groundnut production and management of stem rot, their indiscriminate use for the control of the disease has led to several environmental problems. Thus, other alternative disease management options were considered among which biological control appears to be promising. Biological control with potential actinomycetes is receiving greater attention all over the world. Roving survey was conducted in groundnut growing regions of Andhra Pradesh. 50 actinomycete isolates were isolated, twenty actinomycete isolates were tested for their growth rate and antifungal activity against groundnut stem rot pathogen, *S. rolfsii* under *in vitro* conditions using dual culture method. Among twenty isolates of actinomycetes, five isolates showed maximum inhibition of *S. rolfsii*. These five isolates were characterized based on cultural, biochemical and molecular characters. Among the five actinomycete isolates (Ggd, Kdr, Kyd, Lrp and Mkc), three potential isolates were selected for preparation of bioformulations. The efficacy of talc-based formulations of Ggd, Kdr and Kyd were evaluated against *S. rolfsii* for their ability to reduce the stem rot incidence of groundnut under glasshouse conditions. Among different treatments, (T₁₃) seed treatment with talc-based formulation of Ggd isolate @ 5g / kg seed + soil application @ 5 g / 5 kg soil at 30 DAS was found to be superior in reducing the stem rot incidence showing lowest per cent disease incidence of 7.2, 9.6, 17.4 and 26.6 at 30, 60, 90 and 105 DAS respectively.

Keywords: Groundnut, Bioformulation, *Sclerotium rolfsii*, Actinomycetes

Introduction

Groundnut is a versatile food crop which provides food for human, feed for livestock and poultry, manufacturing of artificial fibres and also used as fuel for manufacturing coarse boards and cork substitutes. Groundnut, being a legume crop with root nodules, it improves the soil fertility by the fixation of atmospheric nitrogen. It is also a good organic manure because of its high nitrogen content (7.0 - 8.0%) and other nutrients.

Globally, groundnut is cultivated throughout the tropical, sub-tropical and warm temperate regions of the world (Nwokolo, 1996) [9]. The major production constraints are unreliable and erratic distribution of rainfall and appearance of unpredictable diseases and pests accounting low productivity. Diseases are one of the major constraints responsible for the low productivity. Crop production losses due to plant diseases by pathogenic fungi and bacteria amounts to 13% worldwide which greatly reduces the production, quality and safety of food. Ground nut stem rot caused by *Sclerotium rolfsii* Sacc. damages the crop with pod loss of 30-40 per cent especially near harvest time (Johnson and Subramanyam, 2000) [6]. Due to its wide host range, soilborne nature and lack of disease resistance in existing commercial cultivars management of the stem rot is difficult with chemicals. Consequently, these situations in agriculture need a serious search to identify alternative methods for plant protection, which are environmentally safer and are of natural origin. Biological control methods involving use of natural antagonists of plant pathogens have been suggested as a safe alternative to chemical methods by several workers (Gumede, 2008 and Sharma, 2011) [5, 13]. Biological control with potential actinomycetes is receiving greater attention all over the world. Biological control can successfully implement by the use of actinomycetes as they

are capable of protecting plants against many pathogens. Soil actinomycetes have revealed their wide antifungal activity (Tinatin and Nuzrat, 2006) [14]. Actinomycetes are one of the important promising group of antagonists and root-colonizing microbes which survive in soils.

Hence the present research focussed on isolation, identification and invitro evaluation of actinomycetes and study the efficacy of bioformulation on *Sclerotium rolfii* *in vivo* under glasshouse conditions.

Methodology

Research was carried out in the Department of Plant Pathology at Agricultural College, Mahanandi, Acharya N.G. Ranga Agricultural University, Andhra Pradesh. Rhizospheric soil samples were collected the soils of major groundnut growing areas (10 districts and 20 mandals) of Andhra Pradesh. Isolation of Actinomycetes was done from the soil suspension of 10^{-3} to 10^{-6} dilutions by using Ken Knight and Munaier Agar medium (KA) (Allen, 1953). Isolates of actinomycetes were tested for their ability to inhibit mycelial growth of *S. rolfii* *in vitro* following the dual culture technique (Toumatia *et al.*, 2014) [15]. Based on the results of various morphological and biochemical tests, the organisms were identified upto generic level by referring to the Bergy's manual (Lechevalier, 1989) [8]. For development of formulation of actinomycetes, the isolates were cultivated in Ken Knight's broth. Talc formulation of potential isolates were assessed for its efficacy in controlling stem rot of groundnut under glasshouse conditions. Surface sterilisation of groundnut seeds was performed by sequential dipping in ethanol solution (70% v/v, 3 min), NaClO solution (0.9% w/v, 4 min) followed by washing three times in sterile distilled water (Goudjal *et al.*, 2013) [4].

Autoclaved soils were infested with the *S. rolfii* using a modified method of Sadeghi *et al.* (2012) [11]. Earthen pots (30 cm in diameter) filled with 5 kg soil were infested with 50 g of the pathogen inoculum previously prepared by growing on sorghum grains (50 g autoclaved sorghum grains for uninoculated soil). Pots were then watered with 100 ml sterile distilled water and incubated at room temperature for 7 days to enhance the growth of the pathogen. The *Streptomyces* sp. were used in infested pots by adding 20 ml of talc powder suspension formulation (10 g talc powder watered in 100 ml sterile distilled water) before sowing and after 45 DAS.

Just before sowing, groundnut variety Kadiri - 6 seeds were coated with 0.2% CMC as an adhesive and treated with powder formulation of potential *Streptomyces* isolates at the rate of 5 g kg^{-1} and 10 g kg^{-1} seeds. Five seeds were sown per pot with 3 replicates per each treatment. Nineteen treatments were imposed in this experiment. To know the population of the *Streptomyces* cfu were counted at 30, 75 and 105 DAS.

Replications: 3 Treatments: 19

- **T₁:** Seed treatment with *Streptomyces* sp. Ggd @ 5 g kg^{-1} seed
- **T₂:** Seed treatment with *Streptomyces* sp. Kdr @ 5 g kg^{-1} seed
- **T₃:** Seed treatment with *Streptomyces* sp. Kyd @ 5 g kg^{-1} seed
- **T₄:** Seed treatment with *Streptomyces* sp. Ggd @ 10 g kg^{-1} seed
- **T₅:** Seed treatment with *Streptomyces* sp. Kdr @ 10 g kg^{-1} seed
- **T₆:** Seed treatment with *Streptomyces* sp. Kyd @ 10 g kg^{-1} seed
- **T₇:** Seed treatment with *Streptomyces* sp. Ggd 5 g kg^{-1} seed + soil application with *Streptomyces* sp. Ggd @ 1 g / 5 kg soil
- **T₈:** Seed treatment with *Streptomyces* sp. Kdr 5 g kg^{-1} seed + soil application with *Streptomyces* sp. Kdr @ 1 g / 5 kg soil
- **T₉:** Seed treatment with *Streptomyces* sp. Kyd 5 g kg^{-1} seed + soil application with *Streptomyces* sp. Kyd @ 1 g / 5 kg soil
- **T₁₀:** Seed treatment with *Streptomyces* sp. Ggd 5 g kg^{-1} seed + soil application with *Streptomyces* sp. Ggd @ 2 g / 5 kg soil
- **T₁₁:** Seed treatment with *Streptomyces* sp. Kdr 5 g kg^{-1} seed + soil application with *Streptomyces* sp. Kdr @ 2 g / 5 kg soil
- **T₁₂:** Seed treatment with *Streptomyces* sp. Kyd 5 g kg^{-1} seed + soil application with *Streptomyces* sp. Kyd @ 2 g / 5 kg soil
- **T₁₃:** Seed treatment with *Streptomyces* sp. Ggd @ 10 g kg^{-1} seed + soil application with *Streptomyces* sp. Ggd 5 g / 5 kg soil
- **T₁₄:** Seed treatment with *Streptomyces* sp. Kdr @ 10 g kg^{-1} seed + soil application with *Streptomyces* sp. Kdr 5 g / 5 kg soil
- **T₁₅:** Seed treatment with *Streptomyces* sp. Kyd @ 10 g kg^{-1} seed + soil application with *Streptomyces* sp. Kyd 5 g / 5 kg soil
- **T₁₆:** Seed treatment with Carbendazim @ 2 g kg^{-1} seed
- **T₁₇:** Commercial formulation of *Trichoderma* spp. @ 10 g kg^{-1} seed
- **T₁₈:** Inoculated control (pathogen inoculated)
- **T₁₉:** Un-inoculated Control (without seed & soil treatment)

Per cent stem rot incidence were recorded at 30, 60, 90 and 105 DAS.

The talc- based formulation of potential actinomycete isolate was assessed for its efficacy in controlling stem rot of groundnut under glasshouse conditions. The susceptible groundnut cultivar, K- 6 (Bunch type; duration 105-110 days) was obtained from the Agricultural College Farm, Mahanandi. The fungus, *S. rolfii* was mass multiplied on sorghum seeds (Elad *et al.*, 1980) [2] for 15 days and the inoculum was mixed with the sterilized soil in the ratio of 1:19 in polyethylene bags. The polyethylene bags were shaken vigorously to ensure uniform distribution of the inoculum. Earthen pots (30 cm diameter) were filled up with 5 kg of infested soil and arranged on the glasshouse benches. The pots were incubated for three days before planting. Seeds were treated with the powder formulation of *Streptomyces* sp. at the rate of 5 g and 10 g of powder formulation per kg seed and sown in infested soil. In another set of pots, seed treatment was followed by soil application of talc-based powder formulation at 1 g and 2 g per pot. Seeds were also treated with Carbendazim @ 2 g / kg seed and commercial formulation of *Trichoderma* spp. @ 10 g / kg seed. Soil mixed with pathogen inoculum and seed treated without actinomycetes formulation served as inoculated control. Soil without pathogen inoculum and seed mock-treated with plain talc powder formulation was kept as

un-inoculated control. Five groundnut seeds were planted in each pot. Each pot served as a replicate, and each treatment was replicated three times. Pots were maintained in the glasshouse under controlled environment conditions. The percentage of stem rot incidence was recorded at 30, 60, 90 and 105 days after sowing by counting all plants per pot showing signs and symptoms, dividing by the total plant count per pot and multiplied by 100.

Experiments were conducted in Completely Randomized Design (CRD). Arc sine transformation of data on percentage of stem rot incidence was done and Duncan's multiple range test (DMRT) was first applied to the transformed values and then transferred to the original means. The data were subjected to analysis of variance (ANOVA) using SPSS 13.0 software for windows (SPSS Inc., Chicago, USA). Mean comparisons were performed by Fisher's Protected Least Significant Difference (LSD) test ($P < 0.05$).

Results and Discussion

Roving survey was conducted to collect the isolates of actinomycetes in major groundnut growing areas of Andhra Pradesh. During the survey 180 rhizospheric soil samples were collected from the rhizosphere of healthy groundnut plants in stem rot infected fields. Isolated a total number of fifty morphologically different actinomycetes by soil dilution plate technique using Ken Knight's Agar medium (KA). Basic identification of actinomycetes was done by visual observation, general morphology, spore formation, colony morphology including Gram stain and biochemical tests and an earthy odour. Among other inhabitants of soil samples, the isolates were identified by formation of clearing zones as the major evidence of antibiotics production. Among the fifty, twenty isolates were selected based on the growth rate of isolate on culture medium and clearing zones in dilution plates. All the twenty isolates were further identified as actinomycetes by general biochemical and morphological characters and proved that all were acid-fast negative, Gram stain positive and aerobic with aerial and substrate mycelia of different colors with varying spore chains. The phylogeny of antagonistic actinomycetes was analysed based on the nucleotide sequences of 16S rRNA gene amplified through F243 and A3R. The phylogenetic analysis revealed that the potential actinomycete isolates clustered with respective species of *Streptomyces* belonged to various countries (Sailaja Rani *et al.*, 2023) [12]. These twenty isolates were selected for *in vitro* antagonistic study and were maintained as pure culture by routine microbiological methods on Ken Knight's agar slants. Among twenty isolates of actinomycetes, five isolates namely Ggd (73.72%), Kdr (71.44%), Kyd (70.61%), Lrp (61.33%) and Mkc (52.06%) showed maximum inhibition of *S. rolfsii*. Among the five actinomycete isolates (Ggd, Kdr, Kyd, Lrp and Mkc), three potential isolates were selected for preparation of bioformulations. Glasshouse experiments were conducted for the purpose of further evaluation of the *Streptomyces* spp. as biocontrol agents. The efficacy of talc based formulations of Ggd, Kdr and Kyd were evaluated against *S. rolfsii* for their ability to reduce the stem rot incidence of groundnut under glasshouse conditions. Talc formulation of *Streptomyces* spp. Ggd, Kdr and Kyd were taken for glasshouse study. The data presented in the Table 1. Nineteen treatments were imposed to assess the combined effect of seed and soil

application of *Streptomyces* spp. against stem rot disease of groundnut under pot culture conditions. Per cent disease incidence of stem rot was recorded at 30, 60, 90 and 105 DAS. At 30 DAS stem rot incidence was ranged from 7.2 to 18.6 per cent. Among the treatments, T₁₃ (seed treatment with *Streptomyces* sp. Ggd @ 10 g kg⁻¹ seed + soil application with *Streptomyces* sp. Ggd 5 g / 5 kg soil) was recorded least percent disease incidence of 7.2 and found to be highly effective in controlling stem rot disease and showed a reduction of 61.1 per cent stem rot disease over control which is on par with seed treatment with *Streptomyces* sp. Kyd @ 10 g kg⁻¹ seed + soil application with *Streptomyces* sp. Kyd 5 g / 5 kg soil (T₁₅) (7.8), seed treatment with *Streptomyces* sp. Kdr @ 10 g kg⁻¹ seed + soil application with *Streptomyces* sp. Kdr 5 g / 5 kg soil (T₁₄) (7.9), seed treatment with *Streptomyces* sp. Ggd 5 g kg⁻¹ seed + soil application with *Streptomyces* sp. Ggd @ 2 g / 5 kg soil (T₁₀) (8.1) whereas seed treatment with *Streptomyces* sp. Kyd 5 g kg⁻¹ seed + soil application with *Streptomyces* sp. Kyd @ 2 g / 5 kg soil (T₁₂) (8.2), seed treatment with *Streptomyces* sp. Kdr @ 5 g kg⁻¹ seed + soil application with *Streptomyces* sp. Kdr 2 g / 5 kg soil (T₁₁) (8.3) and seed treatment with *Streptomyces* sp. Ggd 5 g kg⁻¹ seed + soil application with *Streptomyces* sp. Ggd @ 1 g / 5 kg soil (T₇) (8.3). Highest stem rot incidence of 18.6 per cent was recorded in pathogen inoculated control (T₁₈).

There was an increase in incidence of stem rot at 60 DAS compared to 30 DAS in all the treatments. At 60 DAS stem rot incidence was ranged from 9.6 to 24.1%. It is evident from the Table 1 that lowest per cent disease incidence of stem rot (9.6) was recorded in the seed treatment with *Streptomyces* sp. Ggd @ 10 g kg⁻¹ seed + soil application with *Streptomyces* sp. Ggd 5 g / 5 kg soil (T₁₃) by showing a reduction of 60.0 per cent disease over control which is on par with T₁₅, (seed treatment with *Streptomyces* sp. Kyd @ 10 g kg⁻¹ seed + soil application with *Streptomyces* sp. Kyd 5 g / 5 kg soil) (11.1), T₁₄ (seed treatment with *Streptomyces* sp. Kdr @ 10 g kg⁻¹ seed + soil application with *Streptomyces* sp. Kdr 5 g / 5 kg soil) (11.8), T₁₀ (seed treatment with *Streptomyces* sp. Ggd 5 g kg⁻¹ seed + soil application with *Streptomyces* sp. Ggd @ 2 g / 5 kg soil) (11.9) and T₁₁ (seed treatment with *Streptomyces* sp. Kdr 5 g kg⁻¹ seed + soil application with *Streptomyces* sp. Kdr @ 2 g / 5 kg soil) (12.1), seed treatment with *Streptomyces* sp. Kyd 5 g kg⁻¹ seed + soil application with *Streptomyces* sp. Kyd @ 2 g / 5 kg soil (T₁₂) (12.3), seed treatment with *Streptomyces* sp. Ggd 5 g kg⁻¹ seed + soil application with *Streptomyces* sp. Ggd @ 1 g / 5 kg soil (T₇) (13.0) and seed treatment with *Streptomyces* sp. Kyd 5 g kg⁻¹ seed + soil application with *Streptomyces* sp. Kyd @ 1 g / 5 kg soil (T₉) (13.3) which were showed a reduction of 53.8, 50.9, 50.4, 49.8, 49.0, 46.0 and 45.0 per cent over control respectively. Highest stem rot incidence of 24.1 per cent was recorded in pathogen inoculated control (T₁₈) (inoculated). While in other treatments the stem rot disease incidence recorded was minimum.

There was an increase in incidence of stem rot at 90 DAS compared to 30 and 60 DAS in all the treatments. At 90 DAS stem rot incidence ranged from 17.4 to 56.1 per cent. Lowest per cent disease incidence of stem rot (17.4) was recorded in the seed treatment with *Streptomyces* sp. Ggd @ 10 g kg⁻¹ seed + soil application with *Streptomyces* sp. Ggd 5 g / 5 kg soil (T₁₃) which is on par with (T₁₅) seed treatment with *Streptomyces* sp. Kyd @ 10 g kg⁻¹ seed + soil application with *Streptomyces* sp. Kyd 5 g / 5 kg soil (18.5)

and T₁₄ (seed treatment with *Streptomyces* sp. Kdr @ 10 g kg⁻¹ seed + soil application with *Streptomyces* sp. Kdr 5 g / 5 kg soil) (20.9) showed a reduction of 69.0, 67.0 and 62.7 per cent disease over control respectively. Highest stem rot incidence of 56.1 per cent was recorded in pathogen inoculated control (T₁₈). In other treatments the stem rot disease incidence recorded was moderate in (T₁₀) seed

treatment with *Streptomyces* sp. Ggd 5 g kg⁻¹ seed + soil application with *Streptomyces* sp. Ggd @ 2 g / 5 kg soil (24.4%) and seed treatment with *Streptomyces* sp. Kyd 5 g kg⁻¹ seed + soil application with *Streptomyces* sp. Kyd @ 2 g / 5 kg soil (T₁₂) (25.4%) which were showed a reduction of 56.5 and 54.7 per cent over control respectively.

Table 1: Evaluation of talc-based formulation of *Streptomyces* isolates on stem rot incidence at 30, 60, 90 and 105 days after sowing

S. No.	Treatment particulars	Per cent disease incidence* (30 DAS)	Per cent reduction of disease over control	Per cent disease incidence* (60 DAS)	Per cent reduction of disease over control	Per cent disease incidence* (90 DAS)	Per cent reduction of disease over control	Per cent disease incidence* (105 DAS)	Per cent reduction of disease over control
T1	Seed treatment with <i>Streptomyces</i> sp. Ggd @ 5 g kg ⁻¹ seed	10.0 ^{bcd} (18.4)	46.4	14.3 ^b (22.2)	40.8	33.5 ^{cd} (35.3)	40.3	43.3 ^{bc} (41.1)	35.9
T2	Seed treatment with <i>Streptomyces</i> sp. Kdr @ 5 g kg ⁻¹ seed	10.7 ^b (19.1)	42.3	14.8 ^b (22.6)	38.4	36.2 ^{bc} (37.0)	35.4	45.7 ^b (42.5)	32.4
T3	Seed treatment with <i>Streptomyces</i> sp. Kdr @ 5 g kg ⁻¹ seed	10.2 ^{bcd} (18.6)	45.2	14.5 ^b (22.4)	39.7	34.6 ^{bcd} (35.99)	38.4	44.5 ^{bc} (41.8)	34.0
T4	Seed treatment with <i>Streptomyces</i> sp. Ggd @ 10 g kg ⁻¹ seed	9.2 ^{cdefg} (17.7)	50.4	13.6 ^{bc} (21.6)	43.7	31.6 ^{cde} (34.2)	43.6	41.7 ^{bc} (40.2)	38.2
T5	Seed treatment with <i>Streptomyces</i> sp. Kdr @ 10 g kg ⁻¹ seed	9.8 ^{bcd} (18.3)	47.1	14.0 ^b (21.9)	42.0	32.4 ^{cde} (34.7)	42.2	42.8 ^{bc} (40.8)	36.6
T6	Seed treatment with <i>Streptomyces</i> sp. Kyd @ 10 g kg ⁻¹ seed	9.5 ^{bcd} (18.0)	48.8	13.8 ^b (21.8)	42.6	32.0 ^{cde} (34.4)	43.0	41.9 ^{bc} (40.3)	38.0
T7	Seed treatment with <i>Streptomyces</i> sp. Ggd 5 g kg ⁻¹ seed + soil application with <i>Streptomyces</i> sp. Ggd (@ 1 g / 5 kg soil	8.3 ^{efgh} (16.8)	55.2	13.0 ^{bc} (21.1)	46.0	28.0 ^{ef} (31.9)	50.0	39.4 ^{bcd} (38.8)	41.7
T8	Seed treatment with <i>Streptomyces</i> sp. Kdr 5 g kg ⁻¹ seed + soil application with <i>Streptomyces</i> sp. Kdr @ 1 g / 5 kg soil	8.8 ^{defg} (17.2)	52.8	13.5 ^{bc} (21.5)	43.8	31.4 ^{de} (34.1)	44.0	41.6 ^{bcd} (40.1)	38.4
T9	Seed treatment with <i>Streptomyces</i> sp. Kyd 5 g kg ⁻¹ seed + soil application with <i>Streptomyces</i> sp. Kyd @ 1 g / 5 kg soil	8.5 ^{efgh} (17.0)	54.5	13.3 ^{bc} (21.3)	45.0	31.2 ^{de} (33.9)	44.4	40.4 ^{bcd} (39.5)	40.1
T10	Seed treatment with <i>Streptomyces</i> sp. Ggd 5 g kg ⁻¹ seed + soil application with <i>Streptomyces</i> sp. Ggd @ 2 g / 5 kg soil	8.1 ^{efgh} (16.5)	56.5	11.9 ^{bc} (20.2)	50.4	24.4 ^{fg} (29.6)	56.5	34.3 ^{efg} (35.8)	49.1
T11	Seed treatment with <i>Streptomyces</i> sp. Kdr 5 g kg ⁻¹ seed + soil application with <i>Streptomyces</i> sp. Kdr @ 2 g / 5 kg soil	8.3 ^{efgh} (16.7)	55.5	12.1 ^{bc} (20.3)	49.8	27.8 ^{ef} (31.8)	50.4	38.1 ^{cde} (38.1)	43.6
T12	Seed treatment with <i>Streptomyces</i> sp. Kyd 5 g kg ⁻¹ seed + soil application with <i>Streptomyces</i> sp. Kyd @ 2 g / 5 kg soil	8.2 ^{efgh} (16.7)	55.7	12.3 ^{bc} (20.5)	49.0	25.4 ^f (30.2)	54.7	35.5 ^{def} (36.5)	47.5
T13	Seed treatment with <i>Streptomyces</i> sp. Ggd @ 10 g kg ⁻¹ seed + soil application with <i>Streptomyces</i> sp. Ggd 5 g / 5 kg soil	7.2 ^h (15.4)	61.1	9.6 ^c (18.0)	60.0	17.4 ^h (24.6)	69.0	26.6 ^h (31.0)	60.5
T14	Seed treatment with <i>Streptomyces</i> sp. Kdr @ 10 g kg ⁻¹ seed + soil application with <i>Streptomyces</i> sp. Kdr 5 g /	7.9 ^{gh} (16.4)	57.3	11.8 ^{bc} (20.0)	50.9	20.9 ^{gh} (27.2)	62.7	30.3 ^{efgh} (33.4)	55.1

	5 kg soil								
T15	Seed treatment with <i>Streptomyces</i> sp. Kyd @ 10 g kg ⁻¹ seed + soil application with <i>Streptomyces</i> sp. Kyd 5 g / 5 kg soil	7.8 ^{gh} (16.2)	58.0	11.1 ^{bc} (19.4)	53.8	18.5 ^b (25.4)	67.0	28.6 ^{gh} (32.3)	57.6
T16	Seed treatment with Carbendazim @ 2 g kg ⁻¹ seed	10.3 ^{bc} (18.7)	44.6	14.9 ^b (22.7)	38.2	34.9 ^{bcd} (36.2)	37.8	40.3 ^{bcd} (39.4)	40.3
T17	Commercial formulation of <i>Trichoderma</i> spp. @ 10 g kg ⁻¹ seed	10.1 ^{bcd} (18.5)	45.7	14.5 ^b (22.4)	39.7	38.1 ^b (38.1)	32.0	44.2 ^{bc} (41.7)	34.5
T18	Inoculated control (pathogen inoculated)	18.6 ^a (25.5)	0.0	24.1 ^a (29.4)	0.0	56.1 ^a (48.5)	0.0	67.5 ^a (55.3)	0.0
T19	Un-inoculated Control (without seed & soil treatment)	0.0 ⁱ (0.00)	100.0	0.0 ^d (0.00)	100.0	0.0 ⁱ (0.00)	100.0	0.0 ⁱ (0.00)	100.0
	C.V.	5.138		8.524		5.025		5.435	

*Values are mean of three replications

Figures in parentheses represent arcsine transformed values

Means in a column followed by same superscript letters are not significantly different according to DMRT at $P \leq 0.05$.

There was an increase in incidence of stem rot at 105 DAS compared to 90 DAS in all the treatments. At 105 DAS stem rot incidence ranged from 26.6 to 67.5%. It is evident from the Table 1 that lowest per cent disease incidence of stem rot (26.6) was recorded in the seed treatment with *Streptomyces* sp. Ggd @ 10 g kg⁻¹ seed + soil application with *Streptomyces* sp. Ggd 5 g / 5 kg soil (T₁₃) which is on par with T₁₅, (seed treatment with *Streptomyces* sp. Kyd @ 10 g kg⁻¹ seed + soil application with *Streptomyces* sp. KYD 5 g / 5 kg soil) (28.6) and T₁₄ (seed treatment with *Streptomyces* sp. Kdr @ 10 g kg⁻¹ seed + soil application with *Streptomyces* sp. Kdr 5 g / 5 kg soil) (30.3) which showed a reduction of 60.5, 57.6 and 55.1 per cent disease over control. Highest stem rot incidence of 67.5 per cent was recorded in pathogen inoculated control (T₁₈). In other treatments the stem rot disease incidence recorded was minimum in T₁₀ (seed treatment with *Streptomyces* sp. Ggd 5 g kg⁻¹ seed + soil application with *Streptomyces* sp. Ggd @ 2 g / 5 kg soil) (34.3) and T₁₂ (seed treatment with *Streptomyces* sp. Kyd 5 g kg⁻¹ seed + soil application with *Streptomyces* sp. Kyd @ 2 g / 5 kg soil) (35.5) which showed a reduction of 49.1 and 47.5 per cent over control, respectively (Fig. 1). The ability of *Streptomyces* spp. to

efficiently and dominate the use of space and resources, or to activate the plant immune response, may be more important for excluding pathogens and reducing disease incidence.

The antagonism exhibited by *Streptomyces* in laboratory experiments might not necessarily show antagonism under glasshouse experiments. The metabolic activity of *Streptomyces* spp. in the root region plays an important role for plant growth and management of soil borne plant pathogens. The fungistatic effect in the rhizosphere against soil borne plant pathogens may be due to the exudates (secondary metabolites) of *Streptomyces* spp. The variation in population of *Streptomyces* spp. in groundnut rhizosphere under certain conditions is possible due to differences in composition of root exudates (antibiotics). The increase in the population of *Streptomyces* may also be due to increased senescent leaves resulting in good rhizosphere colonization. Hence, in the present study more number of *Streptomyces* colonies were observed in red soils which may be due to more leaf drop that served as food base for colonization of *Streptomyces* spp. Kanti (2005)^[7] stated that actinomycetes has a vital role as a

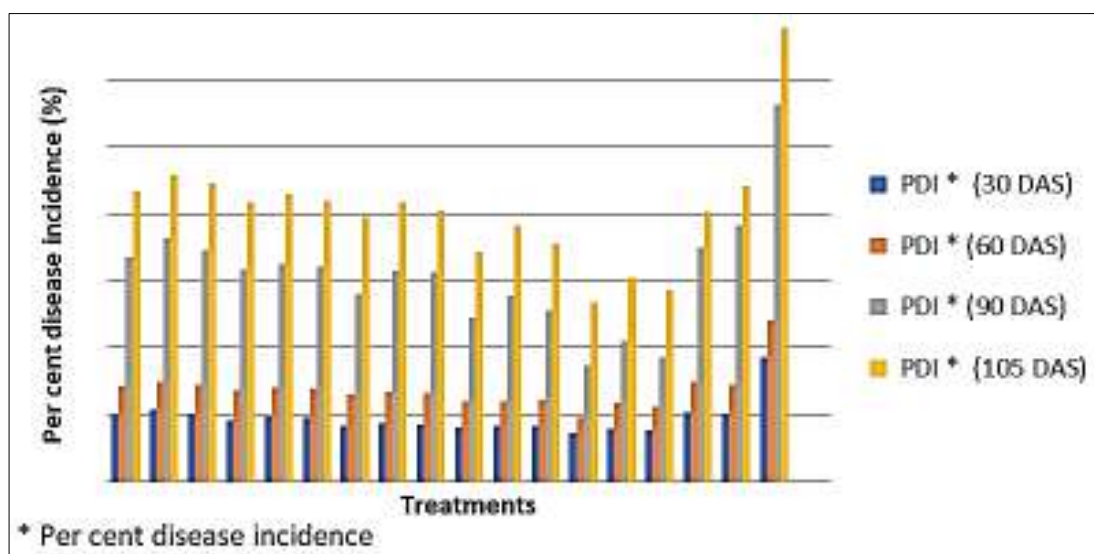


Fig 1: Effect of talc-based *Streptomyces* formulation on stem rot incidence at 30, 60, 90 and 105 days after sowing (DAS)

saprophytic organism which decompose organic material and is essential to increase soil fertility. Several workers have also reported the potential of actinomycetes to control plant diseases (Pattanapitpaisal and Kamlandharn, 2012) [10]. Exposure of the host plant to the heavy inoculum load of the pathogen along with the antagonist will provide ecological data on the performance of the antagonist under glasshouse conditions. Promising antagonists from controlled environment may lead to testing its efficacy under field conditions. The decomposed product of the defoliated leaves might have served as carbon sources and improved microbial activity in the rhizosphere. This results in balanced plant nutrition leading to resistance against the pathogens. Wu *et al.* (2019) [16] reported that a novel antifungalmycin was found to be responsible for the inhibitory effects of *Streptomyces* isolate N2, and when directly applied, was also able to reduce the symptoms of sheath blight on rice leaves in pot culture experiments.

Conclusion

Nineteen treatments were imposed to assess the combined effect of seed and soil application of *Streptomyces* spp. against stem rot disease of groundnut in pot culture under glasshouse conditions. Lowest per cent disease incidence of stem rot was recorded in the T₁₃ (seed treatment with *Streptomyces* sp. Ggd @ 10 g kg⁻¹ seed + soil application with *Streptomyces* sp. Ggd 5 g / 5 kg soil) and found significantly effective. Per cent disease incidence of stem rot recorded at 30, 60, 90 and 105 DAS was 7.2, 9.6, 17.4 and 26.6 per cent respectively.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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Competing Interests

Authors have declared that no competing interests exist.

References

- Allen O. Experiments in soil bacteriology. Minneapolis: Burgess Publishing Company; 1953.
- Elad Y, Chet I, Katan J. *Trichoderma harzianum*: A biocontrol agent effective against *Sclerotium rolfsii* and *Rhizoctonia solani*. *Phytopathology*. 1980;70:119-121.
- Gomes RC, Soares RMA, Alviano CS, Linhares LF, Coelho RRR. Chitinolytic activity of actinomycetes from a cerrado soil and their potential in biocontrol. *Applied Microbiology*. 2000;30:146-150.
- Goudjal Y, Toumatia O, Sabaou N, Barakate M, Mathieu F, Zitouni A. Endophytic actinomycetes from spontaneous plants of Algerian Sahara: Indole-3-acetic acid production and tomato plant-growth-promoting activity. *World Journal of Microbiology and Biotechnology*. 2013;29:1821-1829.
- Gumede H. The development of a putative microbial product for use in crop production [MSc dissertation]. Grahamstown (South Africa): Rhodes University; 2008.
- Johnson M, Subramanyam K. *In vitro* efficacy of fungicides against stem rot pathogen (*Sclerotium rolfsii*) of groundnut. *Annals of Plant Protection Sciences*. 2000;8:255-257.
- Kanti A. Actinomycetes selulitik dari tanah hutan Taman Nasional Bukit Duabelas, Jambi. *Biodiversitas*. 2005;6(2):85-89.
- Lechevalier HA. A practical guide to generic identification of actinomycetes. In: *Bergey's Manual of Systematic Bacteriology*. Vol. 4. Baltimore (USA): Williams and Wilkins Company; 1989. p. 2344-2347.
- Nwokolo E. Peanut (*Arachis hypogaea* L.). In: Nwokolo H, Smart J, editors. *Food and feed from legumes and oilseeds*. London: Chapman and Hall; 1996. p. 49-63.
- Pattanapitpaisal P, Kamlandharn K. Screening of chitinolytic actinomycetes for biological control of *Sclerotium rolfsii* stem rot disease of chilli. *Songklanakarin Journal of Science and Technology*. 2012;34(4):387-393.
- Sadeghi A, Karimi E, Dahaji PA, Javid MG, Dalvand Y, Askari H. Plant-growth-promoting activity of an auxin- and siderophore-producing isolate of *Streptomyces* under saline soil conditions. *World Journal of Microbiology and Biotechnology*. 2012;28:1503-1509.
- Sailaja Rani J, Reddi Kumar M, Khayum Ahammed S, Koteswara Rao SR, Ravindra Reddy B, Sarada Jayalakshmi R, *et al.* Molecular characterization of *Streptomyces* species: effective biocontrol agents of stem rot disease in groundnut. *Scientist*. 2023;4(4):332-339.
- Sharma P. Complexity of *Trichoderma-Fusarium* interaction and manifestation of biological control. *Australian Journal of Crop Science*. 2011;5(8):1027-1038.
- Tinatin D, Nurzat T. Biodiversity of *Streptomyces* of high-mountain ecosystems of Kyrgyzstan and its biotechnological potential. *Antonie van Leeuwenhoek*. 2006;89:325-328.
- Toumatia O, Yekkour A, Goudjal Y, Riba A, Coppel Y, Mathieu F, Zitouni A, *et al.* Antifungal properties of an actinomycin-D-producing strain, *Streptomyces* sp. IA1, isolated from Saharan soil. *Journal of Basic Microbiology*. 2014;54:1-8.
- Wu ZM, Yang Y, Li KT. Antagonistic activity of a novel antifungalmycin N2 from *Streptomyces* sp. N2 and its biocontrol efficacy against *Rhizoctonia solani*. *FEMS Microbiology Letters*. 2019;366:1-7.