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EFFECT OF *TRICHODERMA* SPP. AND NEEM LEAF EXTRACT ON STEM ROT OF GROUNDNUT (*ARACHIS HYPOGEAE* L.) CAUSED BY *SCLEROTIUM ROLFSII*

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ABSTRACT

Groundnut (*Arachis hypogaea* L.) is a vital oilseed crop widely cultivated across tropical and subtropical regions, serving as an important source of edible oil, protein, and income for millions of farmers. However, its productivity is often threatened by stem rot disease, caused by the soil-borne fungus *Sclerotium rolfsii*. This pathogen thrives in warm, humid conditions and can lead to significant crop losses, making it a major concern for growers. With growing awareness of the negative impacts of chemical fungicides on the environment and the risk of pathogen resistance, there is a pressing need for safer, more sustainable disease management strategies. In response to this challenge, the present study—titled *"Effect of Trichoderma spp. and Neem Leaf Extract on Stem Rot of Groundnut* (*Arachis hypogaea L.*) *Caused by Sclerotium rolfsii"*—was designed to explore eco-friendly alternatives. Specifically, it focused on evaluating the effectiveness of beneficial fungi from the *Trichoderma* genus and neem (*Azadirachta indica*) leaf extract as biocontrol agents. The goal was not only to reduce the impact of stem rot but also to promote healthier plant growth and improve overall crop yield in a more environmentally responsible way.

A field experiment was laid out using a Randomized Block Design (RBD) comprising seven treatments with three replications. The treatments involved seed treatment (S.T.) with five *Trichoderma* species—*T. harzianum*, *T. virens*, *T. reesei*, *T. hamatum*, and *T. asperellum*—each combined with a foliar spray (F.S.) of neem (*Azadirachta indica*) leaf extract at 10% concentration. These were compared against a chemical fungicide control (Carbendazim + Mancozeb @ 0.2%) and an untreated control.

The results of the study clear and significant differences among treatments in terms of plant growth and pod yield. Among the biocontrol options tested, the combination of *Trichoderma harzianum* and neem leaf extract stood out, recording the greatest plant height and number of leaves at 30, 60, and 90 days after sowing—measuring 14.05 cm, 26.22 cm, and 32.30 cm in height, and 25.06, 53.00, and 77.06 leaves per plant, respectively. In terms of yield performance, the same treatment recorded a maximum pod yield of 1.35 tonnes per hectare and highest cost-benefit (C: B) with a value of 1:2.0, highlighting its economic advantage for farmers. While the chemical control (Carbendazim + Mancozeb) also showed effectiveness in managing stem rot, several biocontrol treatments either matched or surpassed it in both growth and yield parameters. These findings reinforce the potential of integrating *Trichoderma* species with neem extract as a promising, eco-friendly alternative to conventional fungicides in sustainable groundnut cultivation.

***Key words*:** Groundnut, Neem leaf extract, Plant height, *Sclerotium rolfsii*, *Trichoderma* spp

Introduction

Groundnut (*Arachis hypogaea* L.), commonly referred to as peanut (2n = 40), is a self-pollinated, annual leguminous crop belonging to the family *Fabaceae*. It is cultivated extensively in both tropical and subtropical climates due to its adaptability to a wide range of soil types and climatic conditions. Groundnut holds significant agronomic and economic value, primarily because of its high nutritional content. The seeds are an excellent source of plant-based proteins, unsaturated fatty acids, complex carbohydrates, dietary fiber, essential vitamins (such as vitamin E and B-complex), and key minerals like magnesium, phosphorus, and potassium (Syed *et al.,* 2020). Because of its oil-rich seeds and multipurpose utility, groundnut is often referred to as the "King of Oilseeds." Globally, it stands as the third most important oilseed crop after soybean and rapeseed, while in India, it occupies the second position after soybean in terms of production.

India has the distinction of having the largest area dedicated to groundnut cultivation; however, it ranks second in global production, next to China, which continues to lead both in terms of output and domestic consumption. Over the past six years, India has observed an average annual decline of approximately 3.37% in the area under groundnut cultivation. This trend is largely attributed to the diversification of cropping systems and increased preference for commercial crops such as cotton in several regions. Despite the decline in cultivated area, groundnut productivity and total production in India have shown promising improvements, increasing at annual rates of 4.68% and 6.51%, respectively. These gains are primarily the result of improved agronomic practices, adoption of high-yielding and drought-tolerant varieties, and better input management (Suthar *et al.,*2024).

On a regional level, Gujarat dominates groundnut production in India, accounting for nearly 50% of the national output. Other key contributing states include Andhra Pradesh, Tamil Nadu, and Rajasthan, which together form the backbone of India's groundnut-producing zones. Beyond domestic significance, India plays a pivotal role in the international groundnut trade. The country contributes about 36% to global groundnut exports, positioning itself as a major exporter. Key international markets for Indian groundnuts include countries such as Indonesia, Vietnam, Malaysia, the United Arab Emirates, the Philippines, and Thailand. Over the past decade, the export performance of Indian groundnuts has strengthened considerably, with export volumes and values rising by approximately 14.26% and 24.87% per annum, respectively (Bansal *et al.,* 2017). This upward trend reflects the growing demand for Indian groundnuts in international markets due to their quality, competitiveness, and diverse end-use applications in food, confectionery, and oil industries.

Groundnut cultivation encounters significant difficulties due to a range of fungal pathogens that affect seeds and soil, such as *Aspergillus niger*, *Sclerotium rolfsii*, and *Macrophomina phaseolina*. These pathogens severely impact crop yields by lowering both the amount and quality of the harvest, resulting in considerable financial losses for growers. Traditionally, farmers have relied heavily on chemical fungicides to manage these diseases. However, overuse and repeated applications have led to the emergence of fungicide-resistant strains, diminishing their effectiveness. Moreover, the environmental pollution and potential health hazards caused by chemical residues have raised serious concerns.

In response to these challenges, biological control agents (BCAs) have gained attention as environmentally friendly and sustainable alternatives to chemical fungicides (Ons *et al.,* 2020). BCAs utilize beneficial microorganisms, such as helpful fungi and bacteria, to combat harmful pathogens naturally, promoting plant health without adverse ecological effects.

Among the various diseases that afflict groundnuts, stem rot, caused by the soil-inhabiting fungus *Sclerotium rolfsii* Sacc., stands out as one of the most severe and widespread threats. This pathogen is responsible for multiple damaging conditions including stem rot, root rot, sclerotial wilt (where hard fungal structures called sclerotia obstruct water movement), and pod rot (Chohan, 1974; Mehan *et al.,* 1995). The disease is known by several names such as Southern blight, Southern stem rot, Sclerotium blight, White mold, and Sclerotium stem rot, though "stem rot" is the term most commonly used by farmers.

Stem rot can cause rapid wilting and plant death, particularly in warm, humid environments, leading to significant crop losses. The fungus survives in soil by forming resilient sclerotia, which can persist for many years, making control efforts difficult. Effective management of this disease requires an integrated approach that includes crop rotation, growing resistant groundnut varieties, improving soil health, and employing biological control strategies to reduce the disease burden and protect yields.

Materials and Methods

This study was carried out during the *Kharif* season of 2024 at the Central Research Field of Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. The materials used and the methods followed for the experiment are outlined below.

Details of Treatments

T_0- Control

T_1- *Trichoderma harzianum* (S.T) + Neem leaf extract 10% (F.S)

T_2- *Trichoderma virens* (S.T) + Neem leaf extract 10% (F.S)

T_3- *Trichoderma reesei* (S.T) + Neem leaf extract 10% (F.S)

T_4- *Trichoderma hamatum* (S.T) + Neem leaf extract 10% (F.S)

T_5- *Trichoderma asperellum* (S.T) + Neem leaf extract 10% (F.S)

T_6- Carbendazim + Mancozeb 0.2% (S.T)

(S. T – Seed treatment, F. S – Foliar Spray)

Procurement of *Trichoderma* spp.

Trichoderma spp. were used in this study were obtained from the division of Plant Pathology. ICAR - IARI, Pusa, New Delhi.

Seed treatment with Bio Agents –

Five different *Trichoderma* spp. were used as biocontrol agent for seed treatment.

- *T. harzianum*
- *T. virens*
- *T. reesei*
- *T. hamatum*
- *T. asperellum.*

Preparation of neem leaf extract

To prepare the neem extract, 10 grams of fresh neem leaves were first washed and air-dried. The leaves were then ground into a fine paste using a mortar and pestle. This paste was mixed with 100 ml of water in a clean container and stirred thoroughly. The mixture was left to soak for 24 hours. After soaking, it was filtered through a strainer or cheesecloth to remove solid particles, resulting in a clear liquid extract. The filtered extract was poured into dark glass bottles to protect it from light, labelled appropriately, and stored in a cool, dark place—preferably in a refrigerator. The extract was either used directly or diluted as needed, and applied to plants using a garden sprayer.

Observations recorded in the field:

- Plant height (cm) at 30, 60 and 90 days after sowing (DAS).
- Number of leaves per plant at 30, 60 and 90 days after sowing (DAS)
- Yield (t/ha)

Plant height (cm)

Plant height was measured at 30, 60, and 90 days after sowing (DAS) by selecting five plants at random from each plot. The height was recorded in centimetres, measuring from the base of the plant to the tip of the main shoot.

Number of branches per plant

At 30, 60, and 90 days after sowing (DAS), the number of branches was counted on five randomly selected plants from each plot.

Yield (t/ha)

Plants from the net plot area were harvested, and the developed pods were separated. Any soil particles sticking to the pods were cleaned off, and the pods were then sun-dried. The yield was weighed (t/ha based on the net plot), and the value was used to calculate the final yield in tonnes per hectare.

Cost of cultivation (Rs./ha)

The cost of cultivation for each treatment was calculated separately taking into consideration of all the cultural practices followed in the cultivation.

Gross return (Rs./ha)

The gross return from each treatment was calculated taking into the consideration the market price of the produce.

Net profit (Rs./ha)

The net profit from each treatment was calculated separately by using the following formula:

Net profit (Rs/ha) = Gross return – Total cost of cultivation

Cost benefit ratio (C:B ratio)

The benefit cost ratio from each treatment was determined by using the following formula (Reddy and Reddi, 2004).

$$\text{C:B ratio} = \frac{\text{Gross return}}{\text{Total cost of cultivation}}$$

Result and Discussion

Effect of *Trichoderma* spp. along with Neem leaf extract on plant height (cm) of groundnut at 30, 60 and 90 Days after sowing.

The data presented in Table 1 revealed the plant height (cm) of groundnut at 30, 60 and 90 days after sowing.

At 30 days after sowing plant height (cm) significantly increased in T6- Carbendazim + Mancozeb @0.2% (S.T) (14.7cm) followed by T1- *Trichoderma harzianum* (S.T) + Neem leaf extract @10% (F.S) (14.05cm), T5- *Trichoderma asperellum* (S.T) + Neem leaf extract @10% (F.S) (12.47cm), T4- *Trichoderma hamatum* (S.T) + Neem leaf extract @10% (F.S) (11.18cm), T2- *Trichoderma virens* (S.T) + Neem leaf extract @10%

Table 1: Effect of *Trichoderma* spp. along with Neem leaves on plant height (cm) of groundnut at 30, 60 and 90 days after sowing.

Treatment Number	Treatment Name	Plant height (cm)		
		30DAS	60 DAS	90 DAS
T0	Control	7.10[g]	17.94[g]	26.14[g]
T1	*Trichoderma harzianum* (S.T) + Neem leaf extract 10% (F.S)	14.05[b]	26.22[b]	32.30[b]
T2	*Trichoderma virens* (S.T) + Neem leaf extract 10% (F.S)	9.92[e]	22.42[e]	30.05[e]
T3	*Trichoderma reesei* (S.T) + Neem leaf extract 10% (F.S)	9.00[f]	20.57[f]	28.67[f]
T4	*Trichoderma hamatum* (S.T) + Neem leaf extract 10% (F.S)	11.18[d]	24.30[d]	31.83[d]
T5	*Trichoderma asperellum* (S.T) + Neem leaf extract 10% (F.S)	12.47[c]	25.66[c]	32.20[c]
T6	Carbendazim + Mancozeb 0.2% (S.T)	14.79[a]	26.50[a]	32.87[a]
	CD (5%)	**0.12**	**0.14**	**0.28**

S.T.: Seed Treatment; **F.S.:** Foliar Spray; **DAS:** Days after sowing

(F.S) (9.92cm), and T3- *Trichoderma reeseii* (S.T) + Neem leaf extract @10% (F.S) (9.00cm), as compared to T0- Control (7.10cm).

Comparing the treatments with the CD value (0.12), all the treatments were found to be significant over untreated control (T0). All the treatments were statistically significant to each other.

At 60 days after sowing plant height (cm) significantly increased in T6- Carbendazim + Mancozeb @0.2% (S.T) (26.5cm) followed by T1- *Trichoderma harzianum* (S.T) + Neem leaf extract @10% (F.S) (26.2cm), T5- *Trichoderma asperellum* (S.T) + Neem leaf extract @10% (F.S) (25.6cm), T4- *Trichoderma hamatum* (S.T) + Neem leaf extract @10% (F.S) (24.3cm), T2- *Trichoderma virens* (S.T) + Neem leaf extract @10% (F.S) (22.42cm), and T3- *Trichoderma reeseii* (S.T) + Neem leaf extract @10% (F.S) (20.57cm), as compared to T0- Control (17.94cm).

Comparing the treatments with the CD value (0.14), all the treatments were found to be significant over untreated control (T0). All the treatments were statistically significant to each other.

At 90 days after sowing plant height (cm) significantly increased in T6- Carbendazim + Mancozeb @0.2% (S.T) (32.87cm) followed by T1- *Trichoderma harzianum* (S.T) + Neem leaf extract @10% (F.S) (32.30 cm), T5- *Trichoderma asperellum* (S.T) + Neem leaf extract @10% (F.S) (32.20cm), T4- *Trichoderma hamatum* (S.T) + Neem leaf extract @10% (F.S) (31.83cm), T2- *Trichoderma virens* (S.T) + Neem leaf extract @10% (F.S) (30.0cm), and T3- *Trichoderma reeseii* (S.T) + Neem leaf extract @10% (F.S) (28.67cm), as compared to T0- Control (26.14). Comparing the treatments with the CD value (0.28), all the treatments were found to be significant over untreated control (T0). Among the treatments (T2,T3,T4 and T6) were statistically significant with each other, however, the treatments (T1 and T5) were found to be non-significant.

In the present study, the maximum number of leaves recorded are in T6 (Carbendazim + Mancozeb @0.2 % as seed treatment. Seed treatment with Carbendazim 12% + Mancozeb 63% WP at 3.0 g/kg produced the tallest plants, indicating robust vegetative growth. This enhanced plant height is attributed to effective disease suppression, particularly of seed- and soil-borne pathogens like *Sclerotium rolfsii*, which otherwise hinder nutrient uptake and root development. The improved health of the root system likely contributed to increased shoot elongation and overall plant vigor (Devi, 2015; Kumari *et al.*, 2023; Mahesh *et al.*, 2024).

In contrast, biological control treatments combining five *Trichoderma* spp. with 10% neem leaf extract supported healthy plant growth, though plant height was moderately less than in chemically treated plots. Among these, T_1 - *Trichoderma harzianum* seed treatment plus 10% neem leaf extract foliar spray exhibited the most notable performance, delivering consistent increases in plant stature (though trailing the T_6 treatment).

These biological treatments are believed to improve rhizosphere health and stimulate root activity through multiple mechanisms, including induced systemic resistance (ISR) and enhanced nutrient mobilization via *Trichoderma*'s bioactive metabolites. Studies have demonstrated that *T. harzianum* and related species not only suppress diseases like stem rot but also release hormone-like compounds (e.g., auxin analogues, ACC deaminase) that promote root elongation and shoot development.

In plant height comparisons:

- Chemically treated plots (T_6) achieved the greatest height overall.
- Biocontrol-treated plots, especially those with *T. harzianum* + neem extract (T_1), earned significant gains over the untreated control, often surpassing control heights by 20-30%.

Table 2: Effect of *Trichoderma* spp. along with Neem leaf extract on number of leaves of groundnut at 30, 60 and 90 DAS.

Treatment Number	Treatment Name	No. of Leaves		
		30DAS	60 DAS	90 DAS
T0	Control	18.20[g]	36.13[g]	65.40[g]
T1	*Trichoderma harzianum* (S.T) + Neem leaf extract 10% (F.S)	25.06[b]	53.00[b]	77.06[b]
T2	*Trichoderma virens* (S.T) + Neem leaf extract 10% (F.S)	22.20[e]	45.46[e]	71.60[e]
T3	*Trichoderma reesei* (S.T) + Neem leaf extract 10% (F.S)	20.53[f]	43.46[f]	68.60[f]
T4	*Trichoderma hamatum* (S.T) + Neem leaf extract 10% (F.S)	23.46[d]	47.53[d]	73.60[d]
T5	*Trichoderma asperellum* (S.T) + Neem leaf extract 10% (F.S)	24.53[c]	49.53[c]	75.40[c]
T6	Carbendazim + Mancozeb 0.2% (S.T)	26.53[a]	54.26[a]	79.53[a]
	CD (5%)	**0.51**	**0.61**	**0.64**

S.T.: Seed Treatment; **F.S.:** Foliar Spray; **DAS:** Days after sowing

- Control plots (no treatment) registered the shortest plants, correlating with the highest disease incidence and lowest physiological efficiency.

Disease pressure, particularly from *Sclerotium rolfsii*, tends to stunt growth by impairing root function and nutrient uptake. The healthier root systems in biological treatments likely supported better water and nutrient absorption, translating to stronger shoots and moderate plant height (Taufiq *et al.*, 2020; Suthar *et al.*, 2023; Lavanya *et al.*, 2024).

Effect of *Trichoderma* spp. along with Neem leaves on number of leaves of groundnut at 30, 60 and 90 DAS

The data presented in Table 2 revealed the number of leaves of groundnut at 30, 60 and 90 days after sowing.

At 30 days after sowing number of leaves significantly increased in T6- Carbendazim + Mancozeb @0.2% (S.T) (26.53) followed by T1- *Trichoderma harzianum* (S.T) + Neem leaf extract @10% (F.S) (25.0), T5 - *Trichoderma asperellum* (S.T) + Neem leaf extract @10% (F.S) (24.53), T4- *Trichoderma hamatum* (S.T) + Neem leaf extract @10% (F.S) (23.46), T2- *Trichoderma virens* (S.T) + Neem leaf extract @10% (F.S) (22.2), and T3- *Trichoderma reeseii* (S.T) + Neem leaf extract @10% (F.S) (20.53), as compared to T0- Control (18.20).

Comparing the treatments with the CD value (0.51), all the treatments were found to be significant over untreated control (T0). All treatments were statistically significant to each other.

At 60 days after sowing number of leaves significantly increased in T_6- Carbendazim + Mancozeb @0.2% (S.T) (54.26) followed by T_1- *Trichoderma harzianum* (S.T) + Neem leaf extract @10% (F.S) (53.0), T_5- *Trichoderma asperellum* (S.T) + Neem leaf extract @10% (F.S) (49.53), T_4- *Trichoderma hamatum* (S.T) + Neem leaf extract @10% (F.S) (47.53), T2- *Trichoderma virens* (S.T) + Neem leaf extract @10% (F.S) (45.46), and T_3- *Trichoderma reeseii* (S.T) + Neem leaf extract @10% (F.S) (43.46), as compared to T_0- Control (36.13).

Comparing the treatments with the CD value (0.61), all the treatments were found to be significant over untreated control (T_0). All treatments were statistically significant to each other.

At 90 days after sowing number of leaves significantly increased in T6- Carbendazim + Mancozeb @0.2% (S.T) (79.53) followed by T1- *Trichoderma harzianum*+ Neem leaf extract @10% (F.S) (77.0), T5- *Trichoderma asperellum* + Neem leaf extract @10% (F.S) (75.40), T4- *Trichoderma hamatum* @10% (S.T) + Neem leaf extract @10% (F.S) (73.6), T2- *Trichoderma virens* (S.T) + Neem leaf extract @10% (F.S) (71.6), and T3- *Trichoderma reeseii* (S.T) + Neem leaf extract @10% (F.S) (68.6), as compared to T0- Control (65.40).

Comparing the treatments with the CD value (0.64),

Table 3: Effect of *Trichoderma* spp. along with Neem leaf extract on yield (t/ha) of groundnut.

Treatment Number	Treatment Name	Yield (t/ha)
T0	Control	0.58[gh]
T1	*Trichoderma harzianum* (S.T) + Neem leaf extract 10% (F.S)	1.35[bc]
T2	*Trichoderma virens* (S.T) + Neem leaf extract 10% (F.S)	0.90[ef]
T3	*Trichoderma reesei* (S.T) + Neem leaf extract 10% (F.S)	0.75[fg]
T4	*Trichoderma hamatum* (S.T) + Neem leaf extract 10% (F.S)	1.05[de]
T5	*Trichoderma asperellum* (S.T) + Neem leaf extract 10% (F.S)	1.20[cd]
T6	Carbendazim + Mancozeb 0.2% (S.T)	1.50[a]
	CD (5%)	**0.04**

S.T.: Seed Treatment; **F.S.:** Foliar Spray

Table 4: Economics of treatments (Cost Benefit Ratio).

Tr. No.	Treatments	Yield (t/ha)	Cost of Yield (t/ha)	Gross return (Rs/ha)	Cost of cultivation	Treatment cost (Rs/ha)	Total cost of cultivation (Rs/ha)	C:B Ratio
T0	Control	0.58	55000	31,900	34991	—	34991	1:0.91
T1	*Trichoderma harzianum* (S.T) + Neem leaf extract 10% (F.S)	1.35	55000	74,250	34991	820	35,811	1:2.0
T2	*Trichoderma virens* (S.T) + Neem leaf extract 10% (F.S)	0.90	55000	49,500	34991	820	35,811	1:1.38
T3	*Trichoderma reesei* (S.T) + Neem leaf extract 10% (F.S)	0.75	55000	41,250	34991	820	35,811	1:1.15
T4	*Trichoderma hamatum* (S.T) + Neem leaf extract 10% (F.S)	1.05	55000	57,750	34991	820	35,811	1:1.61
T5	*Trichoderma asperellum* (S.T) + Neem leaf extract 10% (F.S)	1.20	55000	66,000	34991	820	35,811	1:1.84
T6	Carbendazim + Mancozeb 0.2% (S.T)	1.50	55000	82,500	34991	420	35411	1:2.32

all the treatments were found to be significant over untreated control (T0). All the treatments were statistically significant to each other. All treatments were statistically significant to each other.

In the present study, the maximum number of leaves recorded are in T6 (Carbendazim + Mancozeb @0.2 % as seed treatment). Application of Carbendazim 12% + Mancozeb 63% WP as seed treatment at 3.0 g/kg significantly influenced vegetative growth in groundnut. This treatment resulted in the highest number of leaves per plant, indicating enhanced vigor and better plant health due to effective control of seed- and soil-borne pathogens. The increased leaf count contributed to improved photosynthetic activity, which is closely associated with higher yield potential (Devi, 2015; Kumari *et al.*, 2023; Mahesh *et al.*, 2024).

In contrast to chemical treatments, biological interventions combining multiple *Trichoderma* species with neem leaf extract also fostered noticeable vegetative growth in groundnut plants. Although the overall leaf counts were moderate—falling between those seen in chemically treated plots and untreated controls—treatment T_1 (seed treatment with *Trichoderma harzianum* plus a 10% neem leaf extract foliar spray) proved particularly effective at enhancing leaf number. While it did not achieve the exceptionally high leaf counts observed under chemical treatment, it significantly outperformed the untreated control by stimulating canopy development and plant vigor.

These biocontrol treatments are thought to enhance root health through mechanisms such as induced systemic resistance (ISR) and improved nutrient availability. Root colonization by *Trichoderma* spp. promotes hormonal signaling and enzyme production that aids in nutrient uptake and leaf expansion-even under pathogen pressure

Compared to the untreated control—which recorded the fewest leaves due to rampant pathogen infestation (especially *Sclerotium rolfsii*) that stunted canopy development—the T_1 treatment achieved approximately 20–30% more leaves per plant, reflecting healthier physiology and better nutrient assimilation. Disease stress in control plants compromised leaf initiation and overall leaf retention, resulting in sparse foliage and reduced photosynthetic capacity (Taufiq *et al.*, 2020; Suthar *et al.*, 2023; Lavanya *et al.*, 2024).

Although biocontrol treatments did not match chemical fungicides in leaf proliferation, they provided a substantial benefit over untreated plots by promoting healthier growth, more robust leaf development, and better overall plant architecture—without the environmental and resistance concerns associated with chemical use.

Effect of *Trichoderma* spp along with Neem leaves on yield (t/ha) of groundnut.

The data presented in Table 3 revealed that the yield of groundnut significantly increased in T6- Carbendazim + Mancozeb @0.2% (S.T) (1.50) followed by T1- *Trichoderma harzianum* (S.T) + Neem leaf extract @10% (F.S) (1.35), T5- *Trichoderma asperellum* (S.T) + Neem leaf extract @10% (F.S) (1.20), T4- *Trichoderma hamatum* (S.T) + Neem leaf extract @10% (F.S) (1.05), T2- *Trichoderma virens* (S.T) + Neem leaf extract @10% (F.S) (0.90), and T3- *Trichoderma reeseii* (S.T) + Neem leaf extract @10% (FS) (0.75), as compared to T0- Control (0.58).

Comparing the treatments with the CD value (0.04), all the treatments were found to be significant over untreated control (T0). All treatments were statistically significant to each other.

In the present study, maximum yield (t/ha) was shown by T6 (Application of Carbendazim+ Mancozeb @0.2% S.T). Application of Carbendazim 12% + Mancozeb 63% WP at 3.0 g/kg of seed significantly improved plant health and yield parameters in groundnut. This treatment resulted in the highest pod yield of 2,723 kg/ha, with marked reduction in disease incidence, including early leaf spot (7.18 PDI), dry root rot (2.20%), and collar rot (1.98%). Seed germination was also superior at 95.17%, demonstrating the efficacy of this chemical formulation in both disease suppression and growth enhancement (Mahesh *et al.,* 2024).

Among them treatment T1- *Trichoderma harzianum* (S.T) + Neem leaf extract @10% (F.S) demonstrated highly effectiveness. As application of a consortium of five *Trichoderma* species (*T. harzianum, T. viride, T. koningii, T. asperellum, and T. atroviride*) in combination with neem leaf extract as seed treatment and foliar spray effectively managed *Sclerotium rolfsii* under field conditions. The pod yield under these treatments ranged from 2,498 to 2,850 kg/ha, which, although slightly lower than the chemical treatment, was significantly higher than the untreated control. This indicates the potential of biocontrol agents in promoting sustainable disease management (Lavanya *et al.,* 2024).

Conclusion

Based on the findings of this study, the combination of *Trichoderma harzianum* as a seed treatment along with a 10% neem leaf extract foliar spray proved to be the most effective in minimizing the incidence of stem rot caused by *Sclerotium rolfsii* in groundnut (*Arachis hypogaea* L.). This treatment also promoted better plant growth, with the highest recorded plant height and number of leaves. In terms of yield performance and economic return, the treatment involving *Trichoderma harzianum* with neem extract resulted in the highest pod yield and the most favorable cost-benefit (C:B) ratio.

However, it is important to note that these results are based on a single cropping season (Kharif, July–November 2024) conducted under the specific agro-climatic conditions of Prayagraj, Uttar Pradesh, India. To validate and strengthen these findings, additional field trials across multiple seasons and locations are recommended before broader adoption and extension to farmers.

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