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Integrated disease management of Rhizoctonia Blight of Groundnut caused by *Rhizoctonia solani*

Pranaballava S[1*], Gayatri B[1], Mihira K M[1], Shyama S M[2], Abhiram D[3], Jayanta K M[4], Kartik C P[5], Sweta S M[6] & Debashis D[6]

[1]Dept. of Plant Pathology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India- 751003
[2]Dept. of Plant Pathology, Institute of Agricultural Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar, Odisha, India-751030
[3]Dept. of Agricultural Statistics, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India- 751003
[4]AICRP on Nematodes, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India- 751003
[5]AICRP on Groundnut, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India- 751003
[6]Dept. of Agriculture and Allied Sciences, C V Raman Global University, Bhubaneswar, Odisha, India- 752054

*Email: ballava_87@rediffmail.com

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Abstract

Groundnut (*Arachis hypogea* L.) is among the world's principal oilseed crops. Millions of small farmers cultivate it as a valuable cash crop because of its nutritional and economic value. *Rhizoctonia* Blight of Groundnut caused by *Rhizoctonia solani,* is the most destructive disease that causes huge economic losses in most of the groundnut growing regions. An integrated management strategy was used to combine the use of bio-control agents, organic amendments, and fungicides alone as well as in combinations with various delivery methods. The results revealed that application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed was found to be effective with the lowest PDI (17.00 %), maximum germination percentage (97.10%), shoot length (35.3 cm), root length (9.83 cm), number of pods per plant (30.00) and pod yield (3978.86 kg ha^{-1}) with the highest Benefit-Cost ratio (B:C ratio) of 4.60, followed by application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with *T. asperellum* @ 10g/kg of seed with PDI (19.2 %), germination percentage (94.7 %), shoot length (30.6cm), root length (9.61cm), number of pods per plant (27.00) and pod yield (3490.44kg ha^{-1}) with the Benefit-Cost ratio (B:C ratio) of 3.96. All the treatments showed effectiveness in controlling the disease to some extent, but better control and increased yield were recorded in combination treatments compared to single treatments.

Keywords

Germination percentage; AUDPC; percent disease incidence

Introduction

Among legume crops, Groundnut also known as Peanut, belongs to the family Fabaceae and is grown worldwide for its edible seeds. It has a significant impact on both nutritional security and food security. Kernels, also known as groundnut seeds, contain 10-20% carbohydrates, 20-50% protein, and 40-50% fat. Groundnut seeds have vitamin E, niacin, falacin, calcium, phosphorus, magnesium, zinc, iron, riboflavin, thiamine and potassium (1). Groundnuts are currently grown in 108 nations worldwide. With an average yield of 1700 kg per ha and a total production of about

49.56 million metric tonnes, it is grown on 29.75 million hectares globally. Currently, the United States, China, India, Nigeria, Argentina, Sudan, and Senegal are the top seven groundnut-producing nations worldwide (2). Groundnut production is at its maximum in China (18.60 million mt). The yields are highest in the United States in the world (4190 kg/ha) in the cultivated area of 0.64 million hectares. (2). In India, the groundnut crop is planted on around 5.75 million hectares, yielding an average of 1777 kg/ha and producing over 10.297 million tonnes of pods. Hence, India is the world's second-largest producer country (2). The most significant growing states are Gujarat, Rajasthan, Tamil Nadu, Madhya Pradesh, Karnataka, Andhra Pradesh, and Maharashtra. The other states that are growing in Odisha, Chhattisgarh, Bihar, Goa, Haryana, Jharkhand, Kerala, Telangana, Arunachal Pradesh, Manipur, Nagaland, Tripura, Uttarakhand, Puducherry, West Bengal, Punjab, Uttar Pradesh and Himachal Pradesh. Recently, groundnuts have been produced on 0.035 million hectares of land in Odisha, with an average yield of 1610 kg/ha and a total production of 0.057 million tonnes (3). In both the seasons, *kharif* and *rabi*, groundnuts were grown in the Odisha state. The major groundnut growing districts of Odisha are Puri, Cuttack, Jagatsinghpur, Kendrapara, Jajpur, Dhenkanal, Angul, Bargarh, Kalahandi and Mayurbhanj (4). In the rabi season groundnuts were grown mostly in Balangir, Cuttack, Jagatsinghpur, Jajpur, Kendrapara, Dhenkanal, Angul, Ganjam, and Bargarh districts making up 67% of the total groundnut area. However, districts not typically known for cultivating groundnuts, they were Balasore, Subarnapur, Kalahandi, Kandhmal, Boudh, Keonjhar, Koraput, Nabarangpur, Deogarh, and Mayurbhanj, but nowadays we have seen a little increase in acreage planted to the crop in these districts (5).

The groundnut crop is affected by various diseases, insect and pests. Viruses, bacteria, nematodes, and fungi lower the quality of haulm fodder and the groundnut pod yield (6). The major crop-destructing disease is blight disease caused, by the fungus *Rhizoctonia solani*. It has a significant impact on the quality and yield of products all over the world (7). It is one of the most destructive diseases of groundnuts, causing an annual production loss of 20 to 40 percent. All sections of the peanut (*Arachis hypogaea* L.) plant are susceptible to infestation by *Rhizoctonia solani* Kuhn, which has been documented in most of the nations where this crop is cultivated. Drastic reductions in the yield and quality of crop can occur, where conditions are favorable for blight disease development. In India, yield losses occur nearly 31-60% due to blight disease in soybean caused by *Rhizoctonia solani* (8). Significant damage to peanut crops is continuously caused by *Rhizoctonia*-induced diseases, although genotypes, cultural techniques, and other factors also influence losses. *Rhizoctonia* alone or in combination with other diseases including *Pythium, Rhizopus, Fusarium* and *Aspergillus* can cause seed decay and/or seedling damping-off when planted early in chilly, moist soils. (9). Because *Rhizoctonia* blight is transmitted through the soil and persists as sclerotia, a dormant structure, managing the disease in groundnuts has become a difficult task. It has proven feasible to control soil-borne illnesses and seeds only by seed treatment, as chemical soil application has proven to be both costly and impractical (6). Consequently, various optimal solutions for managing diseases were explored, and among them, biological agents show promise and are regarded as a healthy and environmentally safe alternative to fungicides (10, 11). Numerous scientific studies demonstrated that the widespread use of *Trichoderma* species namely, *T. virens*, *T. harzianum*, *T. asperellum*, *T. atroviride*, *T. hamatum*, *T. polysporum* and *T. koningii* as biocontrol agents were successful in combating a range of soil-borne pathogens, including *Phytophthora*, *Sclerotium*, *Fusarium*, and *Rhizoctonia* (12, 13, 14); and organic amendments such as farm yard manure, neem cake, vermicompost found to suppress soil-borne pathogens (15). Several reports also clearly shows that a consortium of bioagents like, P. flourescens and Trichoderma spp. used with organic amendments, found effective in reducing disease incidence and enhancing the growth of plants (16, 17). Therefore, the present study was designed to identify the best management strategy i.e., a biocontrol agent along with organic amendments for the management of *Rhizoctonia solani*, the causal agent of *Rhizoctonia* blight of groundnut, by assessing the treatment of seed as well as soil application of chemical, bioagent and organic amendments.

Materials and Methods

The pathogen

The pathogen was isolated from the groundnut plants, showing symptoms of leaf blight, stem blight, root rot and pod rot. *Rhizoctonia solani* RS1 isolate was submitted to the NCBI GenBank with Accession No. OR541111. On the basis of microscopic visualisation and molecular identification, the pathogen was identified as *Rhizoctonia solani,* which was subsequently mass multiplied in the sorghum grain media. The pathogen was artificially inoculated in each treatment before sowing of the groundnut seed.

Field selection

The sandy loam soil with adequate drainage facilities was used for the field tests at AICRP, Groundnut, Central farm, OUAT, Bhubaneswar, Odisha during the *kharif* season of the year 2022-23 and 2023-24.

Seeds and fertilizers

Urea, single super phosphate and muriate of potash were used to apply the recommended doses of nitrogen, phosphorus and potassium (20-40-40 kg ha^{-1}). For the study, the groundnut seed of the variety "Kadiri Lepakshi" was used. The seeds were purchased from the AICRP, groundnut, OUAT, Bhubaneswar. The fertilizers were purchased from the local markets.

Other inputs

The bioagent *Trichoderma asperellum* was procured from the laboratory of *Trichoderma* production unit,

Department of Plant Pathology, College of Agriculture, OUAT, Bhubaneswar. The chemical fungicide, neem cake and mustard cake were purchased from the local market.

Field layout

Seeds were sown in plots measuring 2.1 × 4.0 m with a spacing of 30 × 10 cm for -105-112 days. All packages of recommended practices for groundnuts were followed. A randomised block design of ten treatments was employed (Fig. 1).

Treatment details

Treatment	Details
T1	Application of neem seed cake to the soil @ 500 kg/ha
T2	Application of mustard seed cake to the soil @ 500 kg/ha
T3	Treatment of seeds with *Trichoderma asperellum* @ 10g/ kg of seed & application of FYM to the soil @ 250 kg/ ha fortified with *T. asperellum* @ 10 kg/ ha
T4	Application of neem seed cake to the soil @ 500 kg/ha + treatment of seeds with *T. asperellum* @10g/kg of seed
T5	Application of mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with *T. asperellum* @ 10g/kg of seed
T6	Treatment of seeds with Tebuconazole @ 1.5g/kg of seed
T7	Treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed
T8	Application of neem seed cake to the soil @ 500 kg/ha + application of mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of
T9	Application of neem seed cake to the soil @ 500 kg/ha + application of mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with *T. asperellum* @ 10g/kg of seed
T10	Control

FYM @ 250 kg/ha was applied to the soil seven days before sowing and all the treatments were replicated thrice.

Parameters analyzed

Percentage of seed germination, percentage of disease incidence at 45, 60 and 75 days after sowing, length of shoots and roots, number of pods per plant, pod yield and Area Under Disease Progress Curve (AUDPC) were among the parameters studied during the field experiment.

The formula used to determine the AUDPC is mentioned below:

$$\sum_{i=1}^{n}\left[\frac{y_i + y_{i+1}}{2}\right][t_{i+1} - t_i]$$

Where,

y_i = Disease incidence recorded at the i^{th} observation

n = Total number of observations.

t_i =Time at the i^{th} observation.

Disease incidence

Percent disease incidence of *Rhizoctonia* blight disease of groundnut was obtained using the following formula.

$$\text{Percent Disease Incidence} = \frac{\text{Number of diseased plants}}{\text{Total number of plants}} \times 100$$

			Border			
	T_1		T_6		T_5	
	T_2		T_7		T_4	
	T_3		T_8		T_3	
	T_4		T_9		T_2	
Border	T_5	**60 Centimeter Drainage Channel**	T_{10}	**60 Centimeter Drainage Channel**	T_7	**Border**
	T_6		T_1		T_9	
	T_7		T_2		T_{10}	
	T_8		T_3		T1	
	T_9		T_4		T_6	
	T10		T_5		T_8	
			Border			

Figure 1. Layout of field experiment trial during *kharif* 2022-23 and *kharif* 2023-24

Statistical analysis

Experimental data were analyzed and analysis of variance (ANOVA) was calculated statistically using RBD with OPSTAT software. Inferences were made based on Critical difference (CD) between the means at 5% level of significance.

Results

After germination of the seeds, the plants were evaluated with regard to disease symptoms using the phenotype characters. The *Rhizoctonia* blight symptoms clearly observed on the plants in each treatment exhibited that the experimental conditions were favourable for infection by the target pathogen, *Rhizoctonia solani* RS1 isolate. The results pertinent to germination percentage, PDI, shoot length, root length, number of pods per plant, and yield are depicted in tables 1, 2, 3 and 4. The overview of the field experiment, effective treatment and control treatment photographs are shown in Fig. 2 (A, B and C) respectively.

During Kharif 2022-23

Germination percentage

Among the ten various treatments tested, T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed) recorded a significantly higher germination percentage (97.0%) followed by T9 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with *T. asperellum* @ 10g/kg of seed) (95.2%), both being statistically at par with each other. The lowest germination percentage (84.0%) was recorded in T10 (control) (Table 1).

(A) Overview of field photo

(B) Effective treatment

(C) Control treatment

Figure 2. (A, B & C) Photographs of the experimental field

Percent disease incidence

At 45 DAS, among different treatments tested against disease incidence, the least PDI (4.60 %) was observed in T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg seed + treatment of seeds with *T. asperellum* @ 10g/kg seed, followed by T9 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with *T. asperellum* @ 10g/kg of seed) of 5.80%. The percent disease incidence of 13.5 was recorded with T2 (application of mustard cake to the soil @ 500 kg/ha) which was statistically at par with T3 (treatment of seeds with *Trichoderma asperellum* @ 10g/kg of seed & application of FYM to the soil @ 250 kg/ ha fortified with *T. asperellum* @ 10 kg/ ha) (11.80% PDI). The highest percent disease incidence of 21.5 was recorded in case of the control treatment (T10) (Table 1).

At 60 DAS, the least PDI of 11.40 was recorded in T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed) being statistically at par with T9 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with *T. asperellum* @ 10g/kg of seed) with 13.50% PDI. T_2 (soil application of mustard cake@ 500 kg/ha) recorded PDI of 27.5% followed by T1 (soil application of Neem seed cake @ 500 kg/ha) with PDI of 25.0%, both being statistically at par with each other. The highest PDI of 35.6% was recorded in the control treatment (T10) (Table 1).

At 75 DAS, a similar trend was noticed in all the treatments. The least PDI of 15.40% was recorded in T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed) which was found to be at par with T9 (soil application of Neem seed cake @ 500 kg/ha + soil application of Mustard seed cake @ 500 kg/ha + seed treatment with *T. asperellum* @ 10g/kg seed) with 17.6% PDI. T2 (application of mustard cake to the soil @ 500 kg/ha) recorded PDI of 32.5 % followed by T1 (soil application of Neem seed cake @ 500 kg/ha) with 29.6% PDI. The control treatment (T10) recorded the highest PDI of 40.5% (Table 1).

At 75 DAS, the highest reduction in disease incidence (61.97%) was recorded in T8 (soil application of Neem seed cake @ 500 kg/ha + soil application of Mustard seed cake @ 500 kg/ha + seed treatment with Tebuconazole @ 1.5g/kg seed + seed treatment with *T. asperellum* @ 10g/kg seed) followed by T9 (soil application of Neem seed cake @ 500 kg/ha + soil application of Mustard seed cake @ 500 kg/ha + seed treatment with *T. asperellum* @ 10g/kg seed), with 56.54% disease reduction and T7 (seed treatment with Tebuconazole @ 1.5g/kg seed + seed treatment with *T. asperellum* @ 10g/kg seed) with 54.32% disease reduction compared to the control treatment.

Table 1. Effect of different treatments on germination percentage and percent disease incidence of *Rhizoctonia* blight disease of groundnut under field conditions during *kharif* 2022-23

Treatments	Germination (%)	Percent disease incidence			% reduction over control	AUDPC
		45 DAS	60 DAS	75 DAS		
T1- Soil application of Neem seed cake @ 500 kg/ha	88.4(70.12)*	12.9 (21.05)	25.0 (30.02)	29.6 (32.98)	26.91	635.65
T2- Soil application of Mustard seed cake @ 500 kg/ha	86.0(68.06)	13.5 (21.57)	27.5 (31.64)	32.5 (34.77)	19.75	758.67
T3- Seed treatment with *Trichoderma asperellum* @ 10g/kg seed & Soil Application of FYM @ 250 kg/ ha fortified with *T. asperellum* @ 10 kg/ ha	89.4(71.04)	11.8 (20.10)	21.4 (27.57)	25.2 (30.15)	37.77	575.65
T4- Soil application of Neem seed cake @ 500 kg/ha + Seed treatment with *T. asperellum* @10g/kg seed	92.5(74.14)	9.1(17.57)	18.5 (25.49)	21.5 (27.64)	46.91	440.00
T5- Soil application of Mustard seed cake @ 500 kg/ha + Seed treatment with *T. asperellum* @ 10g/kg seed	90.4(71.99)	10.2 (18.63)	20.5 (26.94)	22.9 (28.60)	43.45	465.25
T6- Seed treatment with Tebuconazole @ 1.5g/kg seed	92.0(73.61)	9.8(18.25)	17.8 (24.97)	21.5 (27.64)	46.91	440.00
T7- Seed treatment with Tebuconazole @ 1.5g/kg seed + Seed treatment with *T. asperellum* @ 10g/kg seed	94.0(75.86)	8.9(17.37)	14.8 (22.64)	18.5 (25.49)	54.32	424.44
T8- Soil application of Neem seed cake @ 500 kg/ha + Soil application of Mustard seed cake @ 500 kg/ha + Seed treatment with Tebuconazole @ 1.5g/kg seed + Seed treatment with *T. asperellum* @ 10g/kg seed	97.0(80.07)	4.6(12.39)	11.4 (19.74)	15.4 (23.12)	61.97	360.75
T9- Soil application of Neem seed cake @ 500 kg/ha + Soil application of Mustard seed cake @ 500 kg/ha + Seed treatment with *T. asperellum* @ 10g/kg seed	95.2(77.38)	5.8(13.94)	13.5 (21.57)	17.6 (24.82)	56.54	412.65
T_{10}- Control	84.0(67.00)	21.5 (27.64)	35.6 (36.65)	40.5 (39.54)	-	786.25
S.Em±	**2.14**	**0.21**	**0.30**	**0.34**		
CD@0.05 %	**6.37**	**0.62**	**0.90**	**1.01**		

Note: DAS= Days After Sowing ; *Figures in parentheses indicate corresponding angular transformed values.

Area under disease progress curve (AUDPC)

For each treatment, the Area under the Disease Progress Curve (AUDPC) was computed. The results revealed that T10 (control) recorded the highest AUDPC (786.25) while T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed) recorded the least AUDPC (360.75). Among the other combination treatments, the descending order of AUDPC is T5 (465.25) > both T4 & T6 (440.00) > T7 (424.44) > T9 (412.65). Among the single input treatments, the AUDPC order is T2 (758.67) > T1 (635.65) > T3 (575.65) (Table 1).

Impact of treatments on groundnut yield, number of pods per plant, shoot and root lengths

Shoot length and root length

Among various treatments tested, maximum shoot and root length (36.8 cm and 10.02 cm) were recorded in T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed), followed by T9 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with *T. asperellum* @ 10g/kg of seed) with shoot and root length of 32.4 cm and 9.84 cm respectively. The least shoot and root length (21.6 cm and 7.21 cm) were recorded in the control treatment (T10) (Table 2).

No of pods per plant and pod yield

When compared to the control, all the treatments showed noticeably higher yields and pod counts. The highest yield (4000.54 kg/ha) and maximum number of pods per plant (31.00) were recorded in the treatment T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed), followed by T9 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with *T. asperellum* @ 10g/kg of seed) with 3512.12 kg/ha yield and 29.00 number of pods per plant. The least number of pods per plant (15.0) and yield (1200.54 kg/ha) were recorded with the control treatment (T10). The highest increase in grain yield (69.99%) was recorded in T8, followed by T9 (65.81%), T7 (56.39%), T6 (52.73%), T4 (49.00%) and T5 (46.54%) compared to the control treatment (Table 2).

Table 2. Effect of different treatments on growth parameters of groundnut under field condition during *Kharif* 2022-23

Treatments	Shoot length (cm)	Root length (cm)	Number of pods per plant	Yield (Kg/ha)	% increase in yield over control
T1- Soil application of Neem seed cake @ 500 kg/ha	24.0 (29.35)*	7.67 (16.08)	18(25.41)	1869.46	35.78
T2- Soil application of Mustard seed cake @ 500 kg/ha	22.5 (28.33)	7.65 (16.06)	16(23.59)	1756.45	31.62
T3- Seed treatment with *Trichoderma asperellum* @ 10g/kg seed & Soil Application of FYM @ 250 kg/ ha fortified with *T. asperellum* @ 10 kg/ ha	25.4 (30.28)	7.73 (16.15)	21(26.94)	2000.40	39.98
T4- Soil application of Neem seed cake @ 500 kg/ha + Seed treatment with *T. asperellum* @10g/kg seed	28.6 (32.35)	8.10 (16.54)	29(32.28)	2354.00	49.00
T5- Soil application of Mustard seed cake @ 500 kg/ha + Seed treatment with *T. asperellum* @ 10g/kg seed	26.2 (30.80)	7.90 (16.33)	24(29.62)	2246.50	46.54
T6- Seed treatment with Tebuconazole @ 1.5g/kg seed	26.0 (30.67)	8.40 (16.86)	22(27.99)	2540.00	52.73
T7- Seed treatment with Tebuconazole @ 1.5g/kg seed + Seed treatment with *T. asperellum* @ 10g/kg seed	30.0 (33.23)	8.80 (17.27)	25(29.68)	2754.60	56.39
T8- Soil application of Neem seed cake @ 500 kg/ha + Soil application of Mustard seed cake @ 500 kg/ha + Seed treatment with Tebuconazole @ 1.5g/kg seed + Seed treatment with *T. asperellum* @ 10g/kg seed	36.8 (37.37)	10.02 (18.46)	31(33.85)	4000.54	69.99
T9- Soil application of Neem seed cake @ 500 kg/ha + Soil application of Mustard seed cake @ 500 kg/ha + Seed treatment with *T. asperellum* @ 10g/kg seed	32.4 (34.71)	9.84 (18.29)	29(32.35)	3512.12	65.81
T_{10}- Control	21.6 (27.71)	7.21 (15.58)	15(22.80)	1200.54	-
S.Em±	**0.57**	**0.17**	**0.49**	**52.54**	**-**
CD@0.05 %	**1.71**	**0.51**	**1.47**	**156.11**	**-**

*Figures in parentheses indicate corresponding angular transformed values.

During Kharif 2023-24

Germination percentage

Among the various treatments tested against *Rhizoctonia* blight, T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed) recorded significantly the highest germination percentage (97.2%), followed by T9 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with *T. asperellum* @ 10g/kg of seed) (94.1%). Higher germination percentage was observed in all the treatments compared to the control treatment (T10) with the lowest germination percentage of 80.2% (Table 3).

Percent disease incidence

At 45 DAS, the lowest percent disease incidence (5.9%) with the highest disease reduction (57.53%) was recorded with T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed). The treatment with the application of mustard cake to the soil @ 500 kg/ha (T2) showed 14.6% PDI being at par with the application of Neem cake to the soil @ 500 kg/ha (T1) showing 14.3% PDI. The highest PDI of 22.3% was recorded in the control treatment (T10) (Table 3).

The data recorded at 60 DAS revealed that all the treatments were found to record lower PDI than the control treatment. The least PDI (13.4%) was recorded in T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg seed). T2 (application of mustard cake to the soil @ 500 kg/ha) recorded PDI of 29.5% followed by T1 (soil application of Neem seed cake @ 500 kg/ha) with 27.2 % PDI. The control treatment (T10) recorded the highest PDI of 37.8% (Table 3).

A similar trend was observed at 75 DAS where the least PDI (18.6%) was recorded in T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed) with a 57.53% disease reduction. Hence, this was an effective treatment for the management of *Rhizoctonia solani*. T_2 (application of mustard cake to the soil @ 500 kg/ha) recorded PDI of 36.3% being at par with T1 (application of Neem cake to the soil @ 500 kg/ha) with 33.1% PDI. Thus, the lowest disease reduction of 17.12% was recorded in T2. The highest PDI of 43.8% was observed in the control treatment (Table 3).

Area under disease progress curve (AUDPC)

For each treatment, the Area under the Disease Progress Curve (AUDPC) was computed. T10 (control) recorded the highest AUDPC (836.00) while T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed) recorded the least AUDPC (425.00). Among the combination treatments, the descending order of AUDPC is T5 (584.25) > T6 (525.65) > T4 (520.65) > T7 (441.25) > T9 (435.75). Among the single input treatments, the AUDPC order is T2 (802.25) > T1 (780.00) > T3 (692.50) (Table 3).

Table 3. Effect of different treatments on germination percentage and percent disease incidence of *Rhizoctonia* blight disease of groundnut under field conditions during *kharif* 2023-24

Treatments	Germination (%)	Percent disease incidence			% reduction over control	AUDPC
		45 DAS	60 DAS	75 DAS		
T1- Soil application of Neem seed cake @ 500 kg/ha	86.1 (68.17)*	14.3 (22.23)	27.2 (31.47)	33.1 (35.16)	24.42	780.00
T2- Soil application of Mustard seed cake @ 500 kg/ha	84.0 (66.43)	14.6 (22.48)	29.5 (32.89)	36.3 (37.05)	17.12	802.25
T3- Seed treatment with *Trichoderma asperellum* @ 10g/ kg seed & Soil Application of FYM @ 250 kg/ ha fortified with *T. asperellum* @ 10 kg/ ha	87.7 (69.53)	12.8 (21.00)	23.6 (29.10)	30.0 (33.23)	31.50	692.50
T4- Soil application of Neem seed cake @ 500 kg/ha + Seed treatment with *T. asperellum* @10g/kg seed	93.3 (75.07)	10.1 (18.54)	21.3 (27.52)	24.7 (29.79)	43.60	520.65
T5- Soil application of Mustard seed cake @ 500 kg/ha + Seed treatment with *T. asperellum* @ 10g/kg seed	91.0 (72.58)	10.9 (19.26)	22.9 (28.60)	26.1 (30.72)	40.41	584.25
T6- Seed treatment with Tebuconazole @ 1.5g/kg seed	90.5 (72.08)	10.2 (18.60)	20.1 (26.67)	24.9 (29.93)	43.15	525.65
T7- Seed treatment with Tebuconazole @ 1.5g/kg seed + Seed treatment with *T. asperellum* @ 10g/kg seed	93.0 (74.73)	8.9 (17.37)	17.1 (24.41)	21.6 (27.69)	50.68	441.25
T8- Soil application of Neem seed cake @ 500 kg/ha + Soil application of Mustard seed cake @ 500 kg/ha + Seed treatment with Tebuconazole @ 1.5g/kg seed + Seed treatment with *T. asperellum* @ 10g/kg seed	97.2 (80.35)	5.9 (14.11)	13.4 (21.51)	18.6 (25.56)	57.53	425.00
T9- Soil application of Neem seed cake @ 500 kg/ha + Soil application of Mustard seed cake @ 500 kg/ha + Seed treatment with *T. asperellum* @ 10g/kg seed	94.1 (76.02)	6.8 (15.16)	15.6 (23.28)	20.8 (27.17)	52.51	435.75
T_{10}- Control	80.2 (63.59)	22.3 (28.17)	37.8 (37.96)	43.8 (41.44)	-	836.00
S.Em±	1.95	0.42	0.34	0.38	-	-
CD@0.05 %	5.80	1.25	1.03	1.14	-	-

Note: DAS= Days After Sowing ; *Figures in parentheses indicate corresponding angular transformed values.

Effect of treatments on shoot length, root length, number of pods per plant and yield of groundnut

Shoot length and root length

Maximum shoot and root length (33.9 cm and 9.63 cm) were recorded in T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed), followed by T9 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with *T. asperellum* @ 10g/kg of seed), which recorded a root and shoot length of 9.37 cm and 28.8 cm respectively. The control plot (T10) recorded the lowest shoot length (19.3 cm) and root length (6.80 cm) (Table 4).

No of pods per plant and pod yield

The highest yield (3957.17 kg/ha) and highest number of pods per plant (29.00) were recorded in treatment T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed), followed by T9 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with *T. asperellum* @ 10g/kg of seed) with a yield of 3468.75 kg/ha and 26.00 number of pods per plant. Treatment T10 (control) recorded least number of pods per plant (13.00) and yield (1157.17 kg/ha). The highest percent increase in yield (70.75%) was recorded in treatment T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed) followed by T9 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with *T. asperellum* @ 10g/kg of seed) (66.64%). The treatment T2 (soil application of Mustard seed cake @ 500 kg/ha) gave the minimum percent increase in yield (32.45%) compared to control treatment (T10) (Table 4).

In the present investigation, all the treatments were found superior to the control treatment as regards to germination percentage, shoot and root length, number of pods per plant and yield. However, the results revealed that there were variations being observed in germination percentage, percent disease incidence, and growth parameters in the treatments for the consecutive *kharif* seasons of 2022-23 and 2023-24. The results depicted a decline in yield and other parameters as mentioned above in the *Kharif* season of 2023-24 with respect to *Kharif* season 2022-23 due to climatic variations.

Table 4. Effect of different treatments on growth parameters of groundnut under field condition during *kharif* 2023-24

Treatments	Shoot length (cm)	Root length (cm)	Number of pods per plant	Yield (Kg/ ha)	% increase in yield over control
T1- Soil application of Neem seed cake @ 500 kg/ha	20.4 (26.86) *	7.31 (15.70)	16 (23.59)	1826.09	36.63
T2- Soil application of Mustard seed cake @ 500 kg/ha	19.3 (26.10)	7.20 (15.57)	14 (21.98)	1713.08	32.45
T3- Seed treatment with *Trichoderma asperellum* @ 10g/kg seed & Soil Application of FYM @ 250 kg/ ha fortified with *T. asperellum* @ 10 kg/ ha	22.1 (28.08)	7.33 (15.72)	18 (25.36)	1957.03	40.87
T4- Soil application of Neem seed cake @ 500 kg/ha + Seed treatment with *T. asperellum* @10g/kg seed	25.7 (30.45)	7.77 (16.19)	26 (30.67)	2310.63	49.91
T5- Soil application of Mustard seed cake @ 500 kg/ha + Seed treatment with *T. asperellum* @ 10g/kg seed	23.2 (28.79)	7.61 (16.02)	22 (27.76)	2203.13	47.47
T6- Seed treatment with Tebuconazole @ 1.5g/kg seed	24.3 (29.53)	7.97 (16.40)	19 (26.10)	2496.63	53.65
T7- Seed treatment with Tebuconazole @ 1.5g/kg seed + Seed treatment with *T. asperellum* @ 10g/kg seed	27.4 (31.56)	8.37 (16.82)	22 (28.22)	2711.23	57.31
T8- Soil application of Neem seed cake @ 500 kg/ha + Soil application of Mustard seed cake @ 500 kg/ha + Seed treatment with Tebuconazole @ 1.5g/kg seed + Seed treatment with *T. asperellum* @ 10g/kg seed	33.9 (35.61)	9.63 (18.09)	29 (32.60)	3957.17	70.75
T9- Soil application of Neem seed cake @ 500 kg/ha + Soil application of Mustard seed cake @ 500 kg/ha + Seed treatment with *T. asperellum* @ 10g/kg seed	28.8 (32.49)	9.37 (17.84)	26 (30.67)	3468.75	66.64
T_{10}- Control	19.3 (26.07)	6.80 (15.12)	13 (20.86)	1157.17	-
S.Em±	**0.52**	**0.16**	**0.55**	**51.70**	-
CD@0.05 %	**1.55**	**0.47**	**1.66**	**153.62**	-

*Figures in parentheses indicate corresponding angular transformed values.

Pooled data (*Kharif*, 2022-23 and *Kharif*, 2023-24)

The data recorded in *kharif* seasons of both the years were subjected to pooled analysis as regards to parameters like germination percentage, percent disease incidence, root and shoot length and number of pods per plant, yield and AUDPC, B:C ratio and are presented in tables 5 and 6.

Germination percentage

All the treatments recorded higher germination percentages compared to control, but T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed) recorded significantly the highest germination percentage of 97.1%, followed by T9 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with *T. asperellum* @ 10g/kg of seed) with 94.7% germination. The lowest germination percentage (82.1%) was observed in T10 (control) (Table 5).

Percent disease incidence

At 45 DAS, the least PDI (5.3%) was recorded in T8 (soil application of Neem seed cake @ 500 kg/ha + soil application of Mustard seed cake @ 500 kg/ha + seed treatment with Tebuconazole @ 1.5g/kg seed + seed treatment with *T. asperellum* @ 10g/kg seed), followed by T9 (soil application of Neem seed cake @ 500 kg/ha + soil application of Mustard seed cake @ 500 kg/ha + seed treatment with *T. asperellum* @ 10g/kg seed) with PDI of 6.3%, both being statistically at par with each other. T2 (soil application of Mustard seed cake @ 500 kg/ha) recorded disease incidence of 14.1% which was at par with that of T1 (soil application of Neem seed cake @ 500 kg/ ha) with PDI of 13.6%. All the treatments showed reduced disease incidence compared to the control treatment (T10) where the highest percent disease incidence of 21.9 % was recorded (Table 5).

At 60 DAS, all the treatments showed better results in terms of PDI than the control treatment. T8 (soil application of Neem seed cake @ 500 kg/ha + soil application of Mustard seed cake @ 500 kg/ha + seed treatment with Tebuconazole @ 1.5g/kg seed + seed treatment with *T. asperellum* @ 10g/kg seed) was the most effective treatment showing the least disease incidence of 12.40 %, followed by T9 (soil application of Neem seed cake @ 500 kg/ha + soil application of Mustard seed cake @ 500 kg/ha + seed treatment with *T. asperellum* @ 10g/kg seed) with PDI of 14.60%, both being statistically at par with each other. The highest PDI of 36.7% was recorded in the control treatment (T10) (Table 5).

At 75 DAS, a similar trend was observed : T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed) recorded the least disease incidence (17.0%) with the highest percent reduction of disease (59.61%) compared

to the control treatment followed by T9 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with *T. asperellum* @ 10g/kg of seed) with PDI of 19.20% and 54.39% percent reduction of disease over control. The highest PDI of 42.1% was recorded in T10 (control). The least percent reduction of disease (18.28%) over control was recorded in T2 (soil application of Mustard seed cake @ 500 kg/ha) (Table 5).

Area under disease progress curve (AUDPC)

For each treatment, the Area under the Disease Progress Curve (AUDPC) was computed. The same trend could be observed, as mentioned in the previous season. T10 (control) recorded the highest AUDPC (811.12), while T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed), recorded the least AUDPC (392.87). Among the combination treatments the descending order of AUDPC is T5 (524.75) > T6 (482.82) > T4 (480.32) > T7 (392.87) > T9 (424.20). Among the single input treatments, the AUDPC order is T2 (780.46) > T1 (707.82) > T3 (634.07) (Table 5).

Shoot length and root length

Maximum shoot and root length (35.30 cm and 9.83 cm, respectively) was recorded in T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed), followed by T9 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with *T. asperellum* @ 10g/kg of seed), which recorded a root and shoot length of 9.61 cm and 30.60 cm, respectively. The lowest shoot length (20.5 cm) and root length (7.01 cm) were observed in case of T10 (control) (Table 6).

No of pods per plant and pod yield

The highest pod yield (3978.86 kg/ha) with maximum benefit cost ratio (4.60) and number of pods per plant (30.00) were recorded in T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed) with the highest percent increase in yield (70.37%) compared to control. This was followed by T9 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with *T. asperellum* @ 10g/kg of seed) with pod yield of 3490.44 kg/ha, benefit cost ratio of 3.96 and number of pods per plant (27.00). The lowest percent increase in yield (32.04 %) over the control was observed in T2 (soil application of Mustard seed cake @ 500 kg/ha) (Table 6).

Table 5. Pooled data of effect of various treatments on germination percentage and percent disease incidence under field conditions

Treatments	Germination (%)	Percent disease incidence			% reduction over control	AUDPC
		45 DAS	60 DAS	75 DAS		
T1- Soil application of Neem seed cake @ 500 kg/ha	87.3 (69.13) *	13.6 (21.65)	26.1 (30.75)	31.4 (34.08)	25.41	707.82
T2- Soil application of Mustard seed cake @ 500 kg/ha	85.0 (67.23)	14.1 (22.03)	28.5 (32.27)	34.4 (35.92)	18.28	780.46
T3- Seed treatment with *Trichoderma asperellum* @ 10g/kg seed & Soil Application of FYM @ 250 kg/ ha fortified with *T. asperellum* @ 10 kg/ ha	88.6 (70.27)	12.3 (20.56)	22.5 (28.34)	27.6 (31.71)	34.44	634.07
T4- Soil application of Neem seed cake @ 500 kg/ha + Seed treatment with *T. asperellum* @10g/kg seed	92.9 (74.60)	9.6 (18.06)	19.9 (26.52)	23.1 (28.73)	45.13	480.32
T5- Soil application of Mustard seed cake @ 500 kg/ha + Seed treatment with *T. asperellum* @ 10g/kg seed	90.7 (72.28)	10.5 (18.95)	21.7 (27.78)	24.5 (29.67)	41.80	524.75
T6- Seed treatment with Tebuconazole @ 1.5g/kg seed	91.3 (72.83)	10.0 (18.43)	19.0 (25.83)	23.2 (28.80)	44.89	482.82
T7- Seed treatment with Tebuconazole @ 1.5g/kg seed + Seed treatment with *T. asperellum* @ 10g/kg seed	93.5 (75.29)	8.9 (17.37)	15.9 (23.54)	20.0 (26.60)	52.49	432.84
T8- Soil application of Neem seed cake @ 500 kg/ha + Soil application of Mustard seed cake @ 500 kg/ha + Seed treatment with Tebuconazole @ 1.5g/kg seed + Seed treatment with *T. asperellum* @ 10g/kg seed	97.1 (80.21)	5.3 (13.27)	12.4 (20.64)	17.0 (24.36)	59.61	392.87
T9- Soil application of Neem seed cake @ 500 kg/ha + Soil application of Mustard seed cake @ 500 kg/ha + Seed treatment with *T. asperellum* @ 10g/kg seed	94.7 (76.69)	6.3 (14.56)	14.6 (22.43)	19.2 (26.01)	54.39	424.20
T_{10}- Control	82.1 (64.99)	21.9 (27.91)	36.7 (37.31)	42.1 (40.49)	-	811.12
S.Em ±	**1.88**	**0.37**	**0.31**	**0.34**	**-**	**-**
CD @0.05 %	**5.70**	**1.14**	**0.98**	**1.08**	**-**	**-**

Note: DAS= Days After Sowing ; *Figures in parentheses indicate corresponding angular transformed values.

Table 6. Pooled data of effect of various treatments on root and shoot length, number of pods per plant and pod yield under field conditions

Treatments	Shoot length (cm)	Root length (cm)	Number of pods per plant	Yield (Kg/ha)	% increase in yield over control	B:C ratio
T1- Soil application of Neem seed cake @ 500 kg/ha	22.2	7.49	17	1847.78	36.21	1.80
T2- Soil application of Mustard seed cake @ 500 kg/ha	20.9	7.42	15	1734.77	32.04	1.75
T3- Seed treatment with *Trichoderma asperellum* @ 10g/kg seed & Soil Application of FYM @ 250 kg/ ha fortified with *T. asperellum* @ 10 kg/ ha	23.8	7.53	19	1978.72	40.42	1.85
T4- Soil application of Neem seed cake @ 500 kg/ha + Seed treatment with *T. asperellum* @10g/kg seed	27.1	7.93	27	2332.32	49.45	2.40
T5- Soil application of Mustard seed cake @ 500 kg/ha + Seed treatment with *T. asperellum* @ 10g/kg seed	24.7	7.75	23	2224.82	47.01	2.20
T6- Seed treatment with Tebuconazole @ 1.5g/kg seed	25.1	8.18	21	2518.32	53.18	2.50
T7- Seed treatment with Tebuconazole @ 1.5g/kg seed + Seed treatment with *T. asperellum* @ 10g/kg seed	28.7	8.58	23	2732.92	56.86	2.80
T8- Soil application of Neem seed cake @ 500 kg/ha + Soil application of Mustard seed cake @ 500 kg/ha + Seed treatment with Tebuconazole @ 1.5g/kg seed + Seed treatment with *T. asperellum* @ 10g/kg seed	35.3	9.83	30	3978.86	70.37	4.60
T9- Soil application of Neem seed cake @ 500 kg/ha + Soil application of Mustard seed cake @ 500 kg/ha + Seed treatment with *T. asperellum* @ 10g/kg seed	30.6	9.61	27	3490.44	66.22	3.96
T_{10}- Control	20.5	7.01	14	1178.86	-	1.10
S.Em±	**0.47**	**0.13**	**0.53**	**50.20**	-	-
CD@0.05 %	**1.41**	**0.40**	**1.60**	**150.20**	-	-

Discussion

Among all diseases of groundnut, the pathogen with the potential to reduce production and economic benefit is *Rhizoctonia* blight disease, caused by *Rhizoctonia solani,* which has abroad host range for its survival. The most widely used management practice is chemical control, which has detrimental effects on the environment (18). The combination of biocontrol agents with herbal kunapajal was exploited under bio-intensive disease management for the control of *Rhizoctonia solani* in the sheath blight disease of rice which increased yield attributing characters as well as yield (19). The integration of cultural, chemical, and biological management practices exhibits a synergistic effect on the management of stem rot in groundnut and enhances yield (6). This might be the result of using an organic amendment, bioagent, and chemical fungicide in combination. The promotion of plant growth is exhibited by the utilization of organic amendments along with biocontrol agents in the combination treatments by controlling the dry root rot of the mungbean pathogen caused by *Rhizoctonia bataticola,* thereby enhancing yield (20). The results are in agreement with several earlier research work (21-34) which mentioned enhanced disease control of *Rhizoctonia solani* in various crops when fungicides, bioagents, and organic amendments were integrated. Although meager work has been carried out on the groundnut crop concerning *Rhizoctonia* blight, much work has been carried out on various other crops infected by *Rhizoctonia solani*. Thus, the outcome of the present study aligns with the research findings in other crops like fenugreek (23), peas (26), rapeseed (35), cauliflower (36), chili (37) as regards the management of *Rhizoctonia solani,* and they have clearly shown that the integration of organic amendments, biocontrol agents, and chemicals not only controlled the disease incidence but also improved crop growth and production in comparison to the application of individual input management practices.

Conclusion

The present investigation clearly depicted that the combined application of organic amendments, bioagents, and chemical fungicides was effective in reducing disease incidence as well as enhancing growth parameters and yield in comparison with individual treatments with fungicides, bioagents, or organic amendments. In comparison to solitary treatments comprising only fungicide, bioagent or organic amendment, the PDI was found to be lowest in combination treatments. Regarding root and shoot length, the number of pods per plant, and pod yield, the same pattern was also observed. The results clearly depicted that the treatment T8 (application of Neem seed cake to the soil @ 500 kg/ha + application of Mustard seed cake to the soil @ 500 kg/ha + treatment of seeds with Tebuconazole @ 1.5g/kg of seed + treatment of seeds with *T. asperellum* @ 10g/kg of seed) recorded significantly higher germination percentage (97.1%), least disease incidence (17.0 %) with highest percent reduction (59.61%) of disease over control, least AUDPC (392.87), maximum shoot and root length (35.30 cm and 9.83 cm), highest yield and number of pods per plant (3978.86 kg/ha and 30.00). Hence, this treatment was superior to all other treatments for effectively managing *Rhizoctonia* blight in the Kadiri Lepakshi cultivar, and there was an almost three -fold increase in yield with the highest benefit cost ratio (4.60) in comparison to the control. The efficacy of a

combination of organic amendments, biocontrol agents, and chemicals showed better results in managing the disease in groundnut as well as increasing the yield. Though a similar trend of disease management with enhanced yield was reported earlier by many workers in different other crops, the same report in case of groundnut crop was reported by few workers (6, 7, 24, 27, 35) which is confirmed by the present findings. However, further research needs to be carried out on the mechanism of yield enhancement due to the combined use of bioagents, organic amendments, and chemicals in addition to the management of disease caused by *Rhizoctonia solani* in groundnut crop to generate a concrete recommendation for the farmers of the state.

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Authors' contributions

Conceptualization, PS and GB, Methodology, PS and GB, Investigation, PS, Resources, GB, MKM, writing original draft, PS, Formal analysis, SSM, writing review and editing, GB, AD, JKM, KCP, SSM and DD.

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